

**NOVEL HETEROATOM CONTAINING TETRACYCLIC DERIVATIVES AS  
SELECTIVE ESTROGEN RECEPTOR MODULATORS**

**CROSS REFERENCE TO RELATED APPLICATION**

5           This application is a continuation-in-part of U. S. Patent Application 10/307735, filed on December 2, 2002, which is incorporated by reference herein in its entirety.

**Field of the Invention**

10           The present invention is directed to novel heteroatom containing tetracyclic derivatives, pharmaceutical compositions containing them, their use in the treatment of disorders mediated by one or more estrogen receptors and processes for their preparation. The compounds of the invention are thus useful for the treatment and/or prevention of disorders associated with estrogen  
15   depletion (including, but not limited to hot flashes, vaginal dryness, osteopenia, osteoporosis, hyperlipidemia, loss of cognitive function, degenerative brain diseases, cardiovascular and cerebrovascular diseases); for the treatment of hormone sensitive cancers and hyperplasia (in tissues including breast, endometrium, and cervix in women and prostate in men); for the treatment and  
20   prevention of endometriosis, uterine fibroids, and osteoarthritis; and as contraceptive agents either alone or in combination with a progestogen or progestogen antagonist.

**Background of the Invention**

25           Estrogens are a group of female hormones essential for the reproductive process and for the development of the uterus, breasts, and other physical changes associated with puberty. Estrogens have an effect on various tissues throughout a woman's body, not only those involved in the reproductive process, such as the uterus, breasts, and external genitalia, but also tissues in  
30   the central nervous system, bones, the liver, skin, and the urinary tract. The ovaries produce most of the estrogens in a woman's body.

Menopause is defined as the permanent cessation of menses due to loss of ovarian follicular function and the near complete termination of estrogen production. The midlife transition of menopause is characterized by a decrease in estrogen that provokes both short-term and long-term symptoms with the vasomotor, urogenital, cardiovascular, skeletal and central nervous systems, such as hot flashes, urogenital atrophy, increased risk of cardiovascular disease, osteoporosis, cognitive and psychological impairment, including an increased risk of cognitive disorders and Alzheimer's disease (AD).

Seventy-five percent of all women experience some occurrence of vasomotor symptoms associated with the onset of menopause such as body sweating and hot flashes. These complaints may begin several years before menopause and in some women may continue for more than 10 years either relatively constant, or as instant attacks without a definable, provoking cause.

Urogenital symptoms associated with the onset of menopause involving the vagina include a sensation of dryness, burning, itching, pain during intercourse, superficial bleeding and discharge, along with atrophy and stenosis. Symptoms involving the urinary tract include a burning sensation during urination, frequent urgency, recurrent urinary tract infections, and urinary incontinence. These symptoms have been reported to occur in up to 50% of all women near the time of menopause and are more frequent a few years after menopause. If left untreated, the problems can become permanent.

Heart attack and stroke are major causes of morbidity and mortality among senior women. Female morbidity from these diseases increases rapidly after menopause. Women who undergo premature menopause are at greater coronary risk than menstruating women of similar age. The presence of serum estrogen has a positive effect on serum lipids. The hormone promotes vasodilation of blood vessels, and enhances the formation of new blood vessels. Thus the decrease in serum estrogen levels in postmenopausal women results in adverse cardiovascular effect. Additionally, it is theorized that

differences in the ability of blood to coagulate may account for the observed difference in the occurrence of heart disease before and after menopause.

The skeleton is under a continuous process of bone degeneration and regeneration in a carefully regulated interaction among the bone cells. These cells are directly affected by estrogen. Estrogen deficiency results in a loss of bone structure, and decrease of bone strength. Rapid loss of bone mass during the year immediately following menopause leads to postmenopausal osteoporosis and increased risk of fracture.

Estrogen deficiency is also one of the causes for the degenerative changes in the central nervous system and may lead to Alzheimer's disease (AD) and decline of cognition. Recent evidence suggests an association between estrogen, menopause and cognition. More particularly, it has been reported that estrogen replacement therapy and the use of estrogen in women may prevent the development of AD and improve cognitive function.

Hormone replacement therapy (HRT) – more specifically estrogen replacement therapy (ERT) - is commonly prescribed to address the medical problems associated with menopause, and also to help hinder osteoporosis and primary cardiovascular complications (such as coronary artery disease) in both a preventive and therapeutical manner. As such, HRT is considered a medical therapy for prolonging the average life span of postmenopausal women and providing a better quality of life.

ERT effectively relieves the climacteric symptoms and urogenital symptoms and has shown some benefits in the prevention and treatment of heart disease in postmenopausal women. Clinical reports have shown that ERT lowered heart attack rates and mortality rates in populations that received ERT versus similar populations not on ERT. ERT initiated soon after menopause may also help maintain bone mass for several years. Controlled

investigations have shown that treatment with ERT has a positive effect even in older women up to age of 75 years.

However, there are numerous undesirable effects associated with ERT that reduce patient compliance. Venous thromboembolism, gallbladder disease, resumption of menses, mastodynia, and a possible increased risk of developing uterine and/or breast cancer are the risks associated with ERT. Up to 30% of women who are prescribed ERT do not fill the prescription, and the discontinuation rate for ERT is between 38% and 70%, with safety concerns, and adverse effects (bloating and break-through bleeding) the most important reasons for discontinuation.

A new class of pharmacological agents known as Selective Estrogen Receptor Modulators or SERMs have been designed and developed as alternatives for HRT. Raloxifene, a nonsteroidal benzothiophene SERM is marketed in the US and Europe for the prevention and treatment of osteoporosis under the trademark of Evista®. Raloxifene has been shown to reduce bone loss and prevent fracture without adversely stimulating endometrial and mammary tissue, though raloxifene is somewhat less efficacious than ERT for protecting against bone loss. Raloxifene is unique and differs significantly from ERT in that it does not stimulate the endometrium and has the potential for preventing breast cancer. Raloxifene has also demonstrated beneficial estrogen agonist effects on cardiovascular risk factors, more specifically through a rapid and sustained decrease in total and low-density lipoprotein cholesterol levels in patients treated with raloxifene. In addition, raloxifene has been shown to reduce plasma concentration of homocysteine, an independent risk factor for atherosclerosis and thromboembolic disease.

However, raloxifene has been reported to exacerbate symptoms associated with menopause such as hot flushes and vaginal dryness, and does not improve cognitive function in senior patients. Patients taking raloxifene



have reported higher rates of hot flashes compared with either placebo or ERT users and more leg cramps than placebo users, although women who took ERT had a higher incidence of vaginal bleeding and breast discomfort than raloxifene or placebo users.

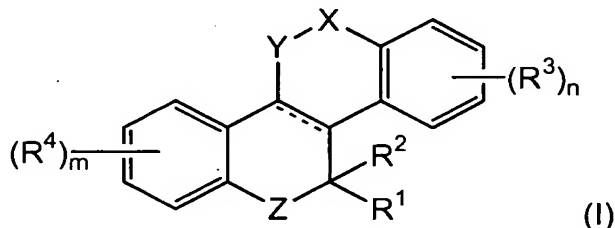
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As yet, neither raloxifene nor any of the other currently available SERM compounds has been shown to have the ability to provide all the benefits of currently available ERT such as controlling postmenopausal syndrome and preventing AD, without causing adverse side effects such as increasing risk of endometrial and breast cancer and bleeding. Thus there exists a need for compounds which are selective estrogen receptor modulators and which provide all of the benefits of ERT while also addressing the vasomotor, urogenital and cognitive disorders or conditions associated with the decrease in systemic estrogen associated with menopause.

15

### Summary of the Invention

The present invention is directed to a compound of formula (I)



wherein

20  $\text{---}$  represents a single or double bond,

X is selected from the group consisting of O and S and Y is selected from the group consisting of  $\text{CR}^{\text{A}}\text{R}^{\text{B}}$ ,  $\text{CR}^{\text{A}}\text{R}^{\text{B}}(\text{CR}^{\text{A}}\text{R}^{\text{B}})_{1-2}$  (preferably  $\text{CR}^{\text{A}}\text{R}^{\text{B}}(\text{CR}^{\text{A}}\text{R}^{\text{B}})_{1-2}$  is selected from  $-\text{CR}^{\text{A}}\text{R}^{\text{B}}(\text{CH}_2)_{1-2}$ ,  $-\text{CH}_2\text{CR}^{\text{A}}\text{R}^{\text{B}}\text{CH}_2-$ ,  $-\text{CR}^{\text{A}}\text{R}^{\text{B}}\text{CH}(\text{OH})-\text{CR}^{\text{A}}\text{R}^{\text{B}}-$  or  $-\text{CR}^{\text{A}}\text{R}^{\text{B}}\text{CH}_2-\text{CR}^{\text{A}}\text{R}^{\text{B}}-$ ),  $\text{CR}^{\text{A}}\text{R}^{\text{B}}\text{C}(\text{O})$ ,  $\text{CR}^{\text{A}}\text{R}^{\text{B}}\text{C}(\text{O})\text{CR}^{\text{A}}\text{R}^{\text{B}}$  (preferably  $\text{CH}_2\text{C}(\text{O})\text{CH}_2$ ), and  $\text{C}(\text{O})$ ; alternatively Y is selected from the group consisting of O and S and X is selected from the group consisting of  $\text{CR}^{\text{A}}\text{R}^{\text{B}}$  and  $\text{C}(\text{O})$ ;

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provided that when X is S, then Y is selected from the group consisting of  $CR^A R^B$ ,  $CR^A R^B (CR^A R^B)_{1-2}$  and  $CH_2C(O)CH_2$ ; provided further that when Y is S, then X is selected from the group consisting of  $CR^A R^B$ ;

wherein each  $R^A$  and  $R^B$  is independently selected from hydrogen,  
 5 hydroxy, alkyl or alkoxy; provided that  $R^A$  and  $R^B$  are not each hydroxy;  
 Z is selected from the group consisting of O and S;

$R^1$  is selected from the group consisting of hydrogen, alkyl, alkenyl, cycloalkyl, aryl, -C(O)-aryl, aralkyl, heteroaryl and heteroaryl-alkyl; wherein the  
 10 alkyl, cycloalkyl, aryl, aralkyl, heteroaryl or heteroaryl-alkyl group is optionally substituted with one or more substituents independently selected from halogen, hydroxy, alkyl, alkoxy, -SH, -S(alkyl),  $SO_2$ ,  $NO_2$ , CN,  $CO_2H$ ,  $R^C$ , -OR<sup>C</sup>, -C(O)-OR<sup>C</sup>, -C(O)O-(alkyl)-NR<sup>D</sup>R<sup>E</sup>, -C(O)-NR<sup>D</sup>-(alkyl)-NR<sup>D</sup>R<sup>E</sup>, -C(O)-(heterocycloalkyl)-NR<sup>D</sup>R<sup>E</sup>, -C(O)-(heterocycloalkyl)-R<sup>F</sup>, - $SO_2$ -NR<sup>D</sup>R<sup>E</sup>, -NR<sup>D</sup>R<sup>E</sup>,  
 15 NR<sup>D</sup>- $SO_2$ -R<sup>F</sup>, -(alkyl)<sub>0-4</sub>-C(O)NR<sup>D</sup>R<sup>E</sup>, (alkyl)<sub>0-4</sub>-NR<sup>D</sup>-C(O)-R<sup>F</sup>, -(alkyl)<sub>0-4</sub>-(Q)<sub>0-1</sub>-(alkyl)<sub>0-4</sub>-NR<sup>D</sup>R<sup>E</sup>, -(alkyl)<sub>0-4</sub>-(Q)<sub>0-1</sub>-(alkyl)<sub>0-4</sub>-C(O)-OR<sup>F</sup>, -(alkyl)<sub>0-4</sub>-(Q)<sub>0-1</sub>-(alkyl)<sub>0-4</sub>-C(O)-NR<sup>D</sup>R<sup>E</sup>, -(alkyl)<sub>0-4</sub>-C(O)-(alkyl)<sub>0-4</sub>-C(O)-OR<sup>F</sup>, -O-(alkyl)-OSI(alkyl)<sub>3</sub>, -O-(alkyl)-OR<sup>D</sup> or -O-(alkyl)-formyl;

20 wherein  $R^C$  is selected from the group consisting of alkyl, cycloalkyl, cycloalkyl-alkyl, aryl, aralkyl, heteroaryl, heteroaryl-alkyl, heterocycloalkyl and heterocycloalkyl-alkyl; wherein the cycloalkyl, cycloalkyl-alkyl, aryl, aralkyl, heteroaryl, heteroaryl-alkyl, heterocycloalkyl or heterocycloalkyl-alkyl group is optionally substituted with one or more substituents independently selected  
 25 from halogen, hydroxy, alkyl, alkoxy, -SH, -S(alkyl),  $SO_2$ ,  $NO_2$ , CN,  $CO_2H$ ,  $R^C$ , - $SO_2$ -NR<sup>D</sup>R<sup>E</sup>, NR<sup>D</sup>R<sup>E</sup>, NR<sup>D</sup>- $SO_2$ -R<sup>F</sup>, -(alkyl)<sub>0-4</sub>-C(O)-NR<sup>D</sup>R<sup>E</sup>, -(alkyl)<sub>0-4</sub>-NR<sup>D</sup>-C(O)-R<sup>F</sup>, -(alkyl)<sub>0-4</sub>-(Q)<sub>0-1</sub>-(alkyl)<sub>0-4</sub>-NR<sup>D</sup>R<sup>E</sup>, -(alkyl)<sub>0-4</sub>-(Q)<sub>0-1</sub>-(alkyl)<sub>0-4</sub>-C(O)-OR<sup>F</sup>, -(alkyl)<sub>0-4</sub>-(Q)<sub>0-1</sub>-(alkyl)<sub>0-4</sub>-C(O)-NR<sup>D</sup>R<sup>E</sup> or -(alkyl)<sub>0-4</sub>-C(O)-(alkyl)<sub>0-4</sub>-C(O)-OR<sup>F</sup>;

30 wherein Q is selected from the group consisting of O, S, NH, N(alkyl) and -CH=CH-;

- wherein each  $R^D$  and  $R^E$  is independently selected from the group consisting of hydrogen and alkyl; alternatively  $R^D$  and  $R^E$  are taken together with the nitrogen atom to which they are bound to form a 3 to 10 membered, preferably 4 to 8 membered, ring selected from the group consisting of
- 5 heteroaryl or heterocycloalkyl; wherein the heteroaryl or heterocycloalkyl group is optionally substituted with one or more substituents independently selected from halogen, hydroxy, oxo, alkyl, alkoxy, carboxy, amino, alkylamino, dialkylamino, nitro or cyano;
- 10 wherein  $R^F$  is selected from the group consisting of hydrogen, alkyl, cycloalkyl, cycloalkyl-alkyl, aryl, aralkyl, heteroaryl, heteroaryl-alkyl, heterocycloalkyl and heterocycloalkyl-alkyl; wherein the cycloalkyl, aryl, heteroaryl, heteroaryl-alkyl, heterocycloalkyl or heterocycloalkyl-alkyl group is optionally substituted with one or more substituents independently selected
- 15 from halogen, hydroxy, alkyl, alkoxy, carboxy, amino, alkylamino, dialkylamino, nitro or cyano;
- $R^2$  is selected from the group consisting of hydroxy, alkyl, alkenyl, cycloalkyl, aryl, -C(O)-aryl, aralkyl, heteroaryl and heteroaryl-alkyl; wherein the
- 20 alkyl, cycloalkyl, aryl, aralkyl, heteroaryl or heteroaryl-alkyl group is optionally substituted with one or more substituents independently selected from halogen, hydroxy, alkyl, alkoxy, -SH, -S(alkyl),  $SO_2$ ,  $NO_2$ , CN,  $CO_2H$ ,  $R^C$ , -OR<sup>C</sup>, -C(O)- $R^C$ , -C(O)O-(alkyl)-NR<sup>D</sup>R<sup>E</sup>, -C(O)-NR<sup>D</sup>-(alkyl)-NR<sup>D</sup>R<sup>E</sup>, -C(O)-(heterocycloalkyl)-NR<sup>D</sup>R<sup>E</sup>, -C(O)-(heterocycloalkyl)-R<sup>F</sup>, - $SO_2$ -NR<sup>D</sup>R<sup>E</sup>, -NR<sup>D</sup>R<sup>E</sup>, NR<sup>D</sup>- $SO_2$ -R<sup>F</sup>, -
- 25 (alkyl)<sub>0-4</sub>-C(O)NR<sup>D</sup>R<sup>E</sup>, (alkyl)<sub>0-4</sub>-NR<sup>D</sup>-C(O)-R<sup>F</sup>, -(alkyl)<sub>0-4</sub>-(Q)<sub>0-1</sub>-(alkyl)<sub>0-4</sub>-NR<sup>D</sup>R<sup>E</sup>, - (alkyl)<sub>0-4</sub>-(Q)<sub>0-1</sub>-(alkyl)<sub>0-4</sub>-C(O)-OR<sup>F</sup>, -(alkyl)<sub>0-4</sub>-(Q)<sub>0-1</sub>-(alkyl)<sub>0-4</sub>-C(O)-NR<sup>D</sup>R<sup>E</sup>, - (alkyl)<sub>0-4</sub>-C(O)-(alkyl)<sub>0-4</sub>-C(O)-OR<sup>F</sup>, -O-(alkyl)-OSi(alkyl)<sub>3</sub>, -O-(alkyl)-OR<sup>D</sup> or -O-(alkyl)-formyl;
- 30 alternatively,  $R^1$  and  $R^2$  are taken together with the carbon atom to which they are bound to form C(O);

provided that when  $R^1$  and  $R^2$  are taken together with the carbon atom to which they are bound to form  $C(O)$  and  $X$  is selected from the group consisting of  $O$  and  $S$ , then  $Y$  is selected from the group consisting of  $CR^A R^B$ ,  $CR^A R^B (CR^A R^B)_{1-2}$ ,  $CR^A R^B C(O)$  and  $CH_2 C(O) CH_2$ ;

5 provided further that when  $R^1$  and  $R^2$  are taken together with the carbon atom to which they are bound to form  $C(O)$  and  $Y$  is selected from the group consisting of  $O$  and  $S$ , then  $X$  is selected from the group consisting of  $CR^A R^B$ ;

$n$  is an integer selected from 0 to 4;

10 each  $R^3$  is independently selected from the group consisting of halogen, hydroxy,  $R^C$ , amino, alkylamino, dialkylamino, nitro, cyano,  $-C(O)R^G$ ,  $-C(O)OR^G$ ,  $-OC(O)R^G$ ,  $-OC(O)OR^G$ ,  $-OC(O)N(R^G)_2$ ,  $-N(R^G)C(O)R^G$ ,  $-OSi(R^G)_3$ ,  $-OR^G$ ,  $-SO_2N(R^G)_2$ ,  $-O-(alkyl)_{1-4}-C(O)R^G$  and  $-O-(alkyl)_{1-4}-C(O)OR^G$ ;

wherein each  $R^G$  is independently selected from hydrogen, alkyl, aryl, 15 aralkyl and 1,7,7-trimethyl-2-oxabicyclo[2.2.1]heptan-3-one; wherein the alkyl, aryl or aralkyl group is optionally substituted with one or more substituents independently selected from alkyl, halogenated alkyl, alkoxy, halogen, hydroxy, nitro, cyano,  $-OC(O)-alkyl$  or  $-C(O)O-alkyl$ ;

alternatively two  $R^G$  groups are taken together with the nitrogen atom to 20 which they are bound to form a heterocycloalkyl group; wherein the heterocycloalkyl group is optionally substituted with one or more substituents independently selected from halogen, hydroxy, alkyl, alkoxy, carboxy, amino, alkylamino, dialkylamino, nitro or cyano;

25  $m$  is an integer selected from 0 to 4;

each  $R^4$  is independently selected from the group consisting of halogen, hydroxy,  $R^C$ , amino, alkylamino, dialkylamino, nitro, cyano,  $-C(O)R^G$ ,  $-C(O)OR^G$ ,  $-OC(O)R^G$ ,  $-OC(O)OR^G$ ,  $-OC(O)N(R^G)_2$ ,  $-N(R^G)C(O)R^G$ ,  $-OSi(R^G)_3$ ,  $-OR^G$ ,  $-SO_2N(alkyl)_2$ ,  $-O-(alkyl)_{1-4}-C(O)R^G$  and  $-O-(alkyl)_{1-4}-C(O)OR^G$ ;

30

provided that when  $==$  is a double bond,  $X$  is  $CH_2$ ,  $Y$  is  $O$ ,  $Z$  is  $O$  and  $R^1$  and  $R^2$  are taken together with the carbon atom to which they are bound to

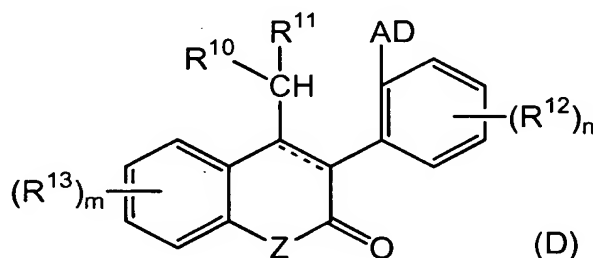
form C(O), then at least one of n or m is an integer selected from 1 to 4;  
preferably, n is an integer from 1 to 4 and m is an integer from 1 to 4;

provided further that when  $\text{---}$  is a single bond, X is O, Y is CH(alkyl),  
5 Z is O, R<sup>1</sup> is hydrogen and R<sup>2</sup> is alkyl, then at least one of n or m is an integer  
selected from 1 to 4; preferably, n is an integer from 1 to 4 and m is an integer  
from 1 to 4;

provided further that when  $\text{---}$  is a single bond, X is O, Y is CH(alkyl),  
Z is O, R<sup>1</sup> is hydrogen, R<sup>2</sup> is alkyl, n is 1 and m is 1, then R<sup>3</sup> and R<sup>4</sup> are other  
10 than methoxy or ethoxy, preferably R<sup>3</sup> and R<sup>4</sup> are other than alkoxy;

provided further that when  $\text{=}$  is a double bond, X is O, Y is CH<sub>2</sub>, Z is  
O, R<sup>1</sup> and R<sup>2</sup> are taken together with the carbon atom to which they are bound  
to form C(O), n is 0 and m is 2, then each R<sup>4</sup> is not hydroxy or alkoxy;  
15 or a pharmaceutically acceptable salt thereof.

The present invention is further directed to a compound of formula (D)



wherein

20  $\text{---}$  represents a single or double bond,

A is selected from the group consisting of O and S;

D is selected from the group consisting of hydrogen, methyl, acetyl,  
benzyl, benzoyl, SEM, MOM, BOM, TBS, TMS, pivaloyl and -C(O)R; wherein  
R is selected from alkyl, aryl, and substituted aryl; wherein the substituents on  
25 the aryl group are one or more independently selected from halogen, hydroxy,  
alkyl, alkoxy, amino, alkylamino, di(alkyl)amino, nitro or cyano;

each R<sup>10</sup> and R<sup>11</sup> is independently selected from hydrogen, halogen,  
hydroxy, alkyl, hydroxy substituted alkyl, alkoxy, -CH(OH)-aryl, -CHO, -C(O)-

alkyl, -C(O)-aryl, -C(O)O-alkyl, -C(O)O-aryl, SEM, MOM, BOM, -CH<sub>2</sub>CH<sub>2</sub>OCH<sub>3</sub>,  
-CH<sub>2</sub>CH<sub>2</sub>-O-benzyl and pivaloyl; wherein the alkyl group, whether alone or as  
part of a larger substituents group is optionally substituted with one or more  
substituents independently selected from hydroxy, halogen or phenyl; wherein  
5 the aryl group, whether alone or as part of a larger substituents group is  
optionally substituted with one or more substituents independently selected  
from hydroxy, alkoxy or alkoxy-carbonyl;

provided that R<sup>10</sup> and R<sup>11</sup> are not each hydrogen or each hydroxy;

Z is selected from the group consisting of O and S;

10 n is an integer selected from 0 to 4;

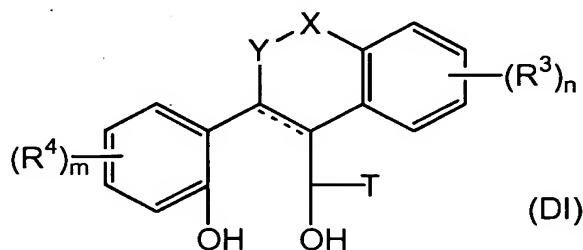
each R<sup>12</sup> is independently selected from the group consisting of halogen,  
hydroxy, alkyl, alkoxy, trialkylsilyl, acyloxy, benzoyloxy, aryloxy, aralkyloxy,  
SEMOxy, MOMoxy and pivaloyloxy;

m is an integer selected from 0 to 4;

15 each R<sup>13</sup> is independently selected from the group consisting of halogen,  
hydroxy, alkyl, alkoxy, trialkylsilyl, acyloxy, benzoyloxy, aryloxy, aralkyloxy,  
SEMOxy, MOMoxy and pivaloyloxy;

or a pharmaceutically acceptable salt thereof.

20 The present invention is further directed to a compound of formula (DI)



wherein

==== represents a single or double bond,

25 X is selected from the group consisting of O and S and Y is selected  
from the group consisting of CR<sup>A</sup>R<sup>B</sup>, CR<sup>A</sup>R<sup>B</sup>(CR<sup>A</sup>R<sup>B</sup>)<sub>1-2</sub> (preferably  
CR<sup>A</sup>R<sup>B</sup>(CR<sup>A</sup>R<sup>B</sup>)<sub>1-2</sub> is selected from -CR<sup>A</sup>R<sup>B</sup>(CH<sub>2</sub>)<sub>1-2</sub>, -CH<sub>2</sub>CR<sup>A</sup>R<sup>B</sup>CH<sub>2</sub>-, -CR<sup>A</sup>R<sup>B</sup>-  
CH(OH)-CR<sup>A</sup>R<sup>B</sup>- or -CR<sup>A</sup>R<sup>B</sup>-CH<sub>2</sub>-CR<sup>A</sup>R<sup>B</sup>-), CR<sup>A</sup>R<sup>B</sup>C(O), CR<sup>A</sup>R<sup>B</sup>C(O)CR<sup>A</sup>R<sup>B</sup>  
(preferably CH<sub>2</sub>C(O)CH<sub>2</sub> and C(O); alternatively Y is selected from the group

consisting of O and S and X is selected from the group consisting of  $CR^A R^B$  and C(O);

provided that when X is S, then Y is selected from the group consisting of  $CR^A R^B$ ,  $CR^A R^B (CR^A R^B)_{1-2}$  and  $CH_2C(O)CH_2$ ; provided further that when Y is

5 S, then X is selected from the group consisting of  $CR^A R^B$ ;

wherein each  $R^A$  and  $R^B$  is independently selected from hydrogen, hydroxy, alkyl or alkoxy; provided that  $R^A$  and  $R^B$  are not each hydroxy;

T is selected from the group consisting of  $-(aryl)-O-(alkyl)-NR^D R^E$  and  $-(aryl)-O-(alkyl)-OH$ ;

10 n is an integer selected from 0 to 4;

each  $R^3$  is independently selected from the group consisting of halogen, hydroxy,  $R^C$ , amino, alkylamino, dialkylamino, nitro, cyano,  $-C(O)R^G$ ,  $-C(O)OR^G$ ,  $-OC(O)R^G$ ,  $-OC(O)OR^G$ ,  $-OC(O)N(R^G)_2$ ,  $-N(R^G)C(O)R^G$ ,  $-OSi(R^G)_3$ ,  $-OR^G$ ,  $-SO_2N(R^G)_2$ ,  $-O-(alkyl)_{1-4}-C(O)R^G$  and  $-O-(alkyl)_{1-4}-C(O)OR^G$ ;

15 wherein  $R^C$  is selected from the group consisting of alkyl, cycloalkyl, cycloalkyl-alkyl, aryl, aralkyl, heteroaryl, heteroaryl-alkyl, heterocycloalkyl and heterocycloalkyl-alkyl; wherein the cycloalkyl, cycloalkyl-alkyl, aryl, aralkyl, heteroaryl, heteroaryl-alkyl, heterocycloalkyl or heterocycloalkyl-alkyl group is optionally substituted with one or more substituents independently selected  
20 from halogen, hydroxy, alkyl, alkoxy,  $-SH$ ,  $-S(alkyl)$ ,  $SO_2$ ,  $NO_2$ ,  $CN$ ,  $CO_2H$ ,  $R^C$ ,  $-SO_2-NR^D R^E$ ,  $NR^D R^E$ ,  $NR^D-SO_2-R^F$ ,  $-(alkyl)_{0-4}-C(O)-NR^D R^E$ ,  $-(alkyl)_{0-4}-NR^D-C(O)-R^F$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-NR^D R^E$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-C(O)-OR^F$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-C(O)-NR^D R^E$  or  $-(alkyl)_{0-4}-C(O)-(alkyl)_{0-4}-C(O)-OR^F$ ;

25 wherein Q is selected from the group consisting of O, S, NH, N(alkyl) and  $-CH=CH-$ ;

wherein  $R^D$  and  $R^E$  are each independently selected from the group consisting of hydrogen and alkyl; alternatively  $R^D$  and  $R^E$  are taken together with the nitrogen atom to which they are bound to form a 3 to 10 membered, preferably 4 to 8 membered, ring selected from the group consisting of  
30 heteroaryl or heterocycloalkyl; wherein the heteroaryl or heterocycloalkyl group is optionally substituted with one or more substituents independently selected

from halogen, hydroxy, oxo, alkyl, alkoxy, carboxy, amino, alkylamino, dialkylamino, nitro or cyano;

wherein  $R^F$  is selected from the group consisting of hydrogen, alkyl, cycloalkyl, cycloalkyl-alkyl, aryl, aralkyl, heteroaryl, heteroaryl-alkyl,

5 heterocycloalkyl and heterocycloalkyl-alkyl; wherein the cycloalkyl, aryl, heteroaryl, heteroaryl-alkyl, heterocycloalkyl or heterocycloalkyl-alkyl group is optionally substituted with one or more substituents independently selected from halogen, hydroxy, alkyl, alkoxy, carboxy, amino, alkylamino, dialkylamino, nitro or cyano;

10 wherein each  $R^G$  is independently selected from hydrogen, alkyl, aryl, aralkyl and 1,7,7-trimethyl-2-oxabicyclo[2.2.1]heptan-3-one; wherein the alkyl, aryl or aralkyl group is optionally substituted with one or more substituents independently selected from alkyl, halogenated alkyl, alkoxy, halogen, hydroxy, nitro, cyano, -OC(O)-alkyl or -C(O)O-alkyl;

15 alternatively two  $R^G$  groups are taken together with the nitrogen atom to which they are bound to form a heterocycloalkyl group; wherein the heterocycloalkyl group is optionally substituted with one or more substituents independently selected from halogen, hydroxy, alkyl, alkoxy, carboxy, amino, alkylamino, dialkylamino, nitro or cyano;

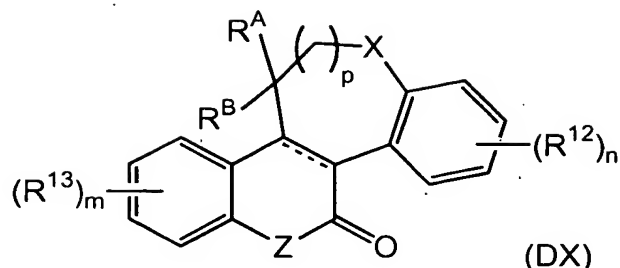
20 m is an integer selected from 0 to 4;

each  $R^4$  is independently selected from the group consisting of halogen, hydroxy,  $R^C$ , amino, alkylamino, dialkylamino, nitro, cyano, -C(O) $R^G$ , -C(O)OR $^G$ , -OC(O) $R^G$ , -OC(O)OR $^G$ , -OC(O)N( $R^G$ )<sub>2</sub>, -N( $R^G$ )C(O) $R^G$ , -OSi( $R^G$ )<sub>3</sub>, -OR $^G$ , -SO<sub>2</sub>N(alkyl)<sub>2</sub>, -O-(alkyl)<sub>1-4</sub>-C(O) $R^G$  and -O-(alkyl)<sub>1-4</sub>-C(O)OR $^G$ ;

25 or a pharmaceutically acceptable salt thereof.

The present invention is further directed to a process for the preparation of a compound of formula (DX)





wherein

----- represents a single or double bond,

X is selected from the group consisting of O and S;

5 p is an integer from 0 to 2;

$R^A$  and  $R^B$  are each independently selected from hydrogen, hydroxy, alkyl or alkoxy; provided that  $R^A$  and  $R^B$  are not each hydroxy;

Z is selected from the group consisting of O and S;

n is an integer from 0 to 4;

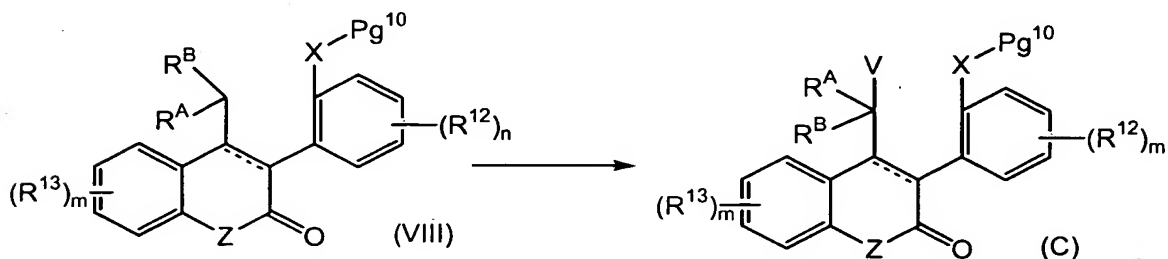
10 each  $R^{12}$  is independently selected from the group consisting of halogen, hydroxy, alkyl, alkoxy, trialkylsilyl, acyloxy, benzoyloxy, aryloxy, aralkyloxy, SEMoxy, MOMoxy and pivaloyloxy;

m is an integer selected from 0 to 4;

15 each  $R^{13}$  is independently selected from the group consisting of halogen, hydroxy, alkyl, alkoxy, trialkylsilyl, acyloxy, benzoyloxy, aryloxy, aralkyloxy, SEMoxy, MOMoxy and pivaloyloxy;

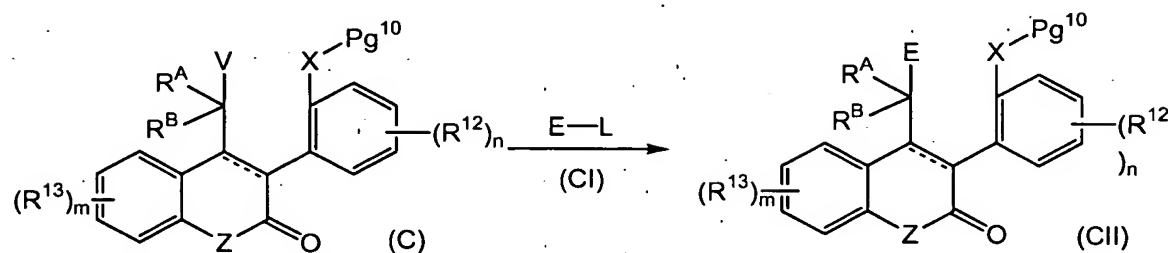
or a pharmaceutically acceptable salt thereof;

comprising

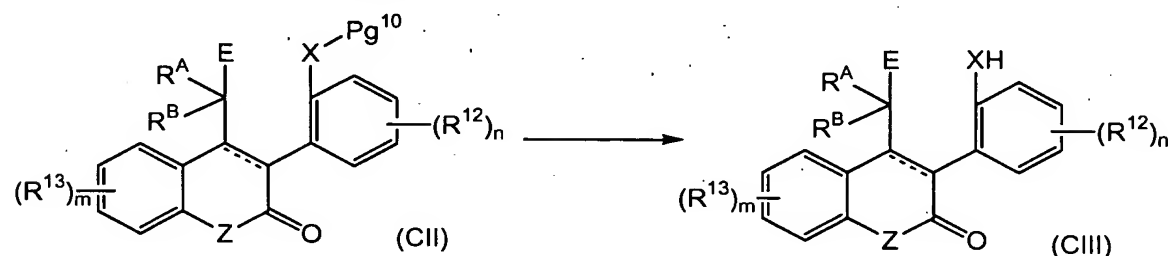


20 reacting a suitable substituted compound of formula (VIII), a known compound or compound prepared by known methods, wherein  $Pg^{10}$  is a protecting group, with an organic base selected from the group consisting of NaHMDS, LiHMDS, KHMDS, LDA and di(lower alkyl)amino lithium, to yield the

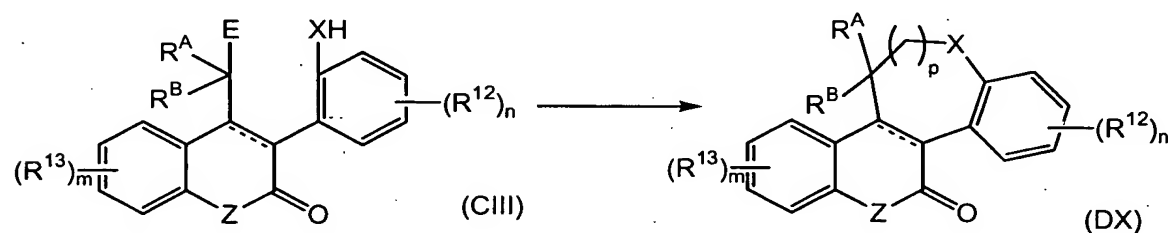
corresponding compound of formula (C), wherein V is the corresponding base cation;



- reacting the compound of formula (C) with a suitably substituted  
 5 compound of formula (CI), wherein E is an electrophile and L is a leaving group, to yield the corresponding compound of formula (CII);

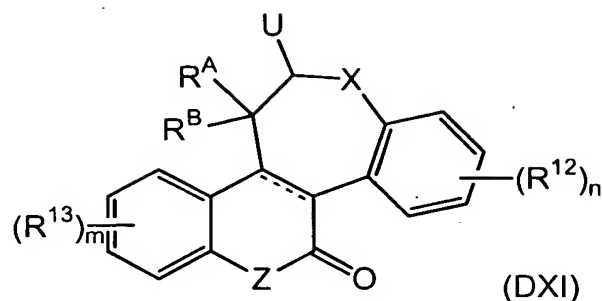


de-protecting the compound of formula (CII), to yield the corresponding compound of formula (CIII);



cyclizing the compound of formula (CIII), to yield the corresponding compound of formula (DX).

- The present invention is further directed to a process for the preparation  
 15 of a compound of formula (DXI)



wherein

— represents a single or double bond,

X is selected from the group consisting of O and S;

5 U is selected from the group consisting of hydrogen and alkyl;

$R^A$  and  $R^B$  are each independently selected from hydrogen, hydroxy, alkyl or alkoxy; provided that  $R^A$  and  $R^B$  are not each hydroxy;

Z is selected from the group consisting of O and S;

n is an integer from 0 to 4;

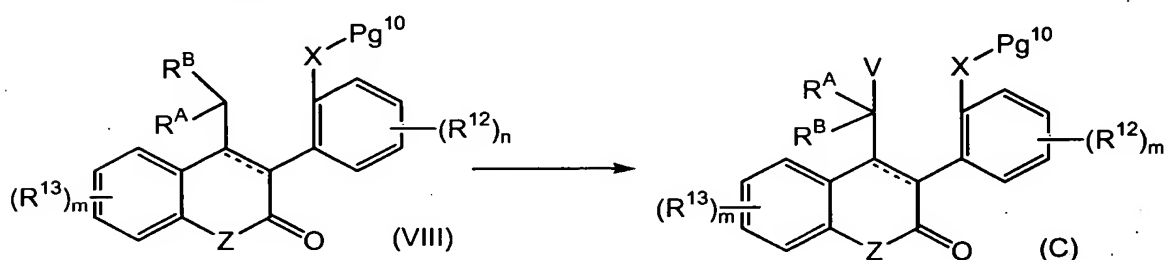
10 each  $R^{12}$  is independently selected from the group consisting of halogen, hydroxy, alkyl, alkoxy, trialkylsilyl, acyloxy, benzoyloxy, aryloxy, aralkyloxy, SEMoxy, MOMoxy and pivaloyloxy;

m is an integer selected from 0 to 4;

15 each  $R^{13}$  is independently selected from the group consisting of halogen, hydroxy, alkyl, alkoxy, trialkylsilyl, acyloxy, benzoyloxy, aryloxy, aralkyloxy, SEMoxy, MOMoxy and pivaloyloxy;

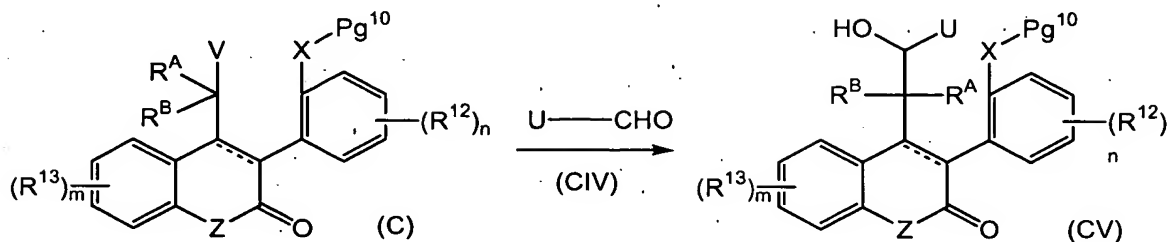
or a pharmaceutically acceptable salt thereof;

comprising

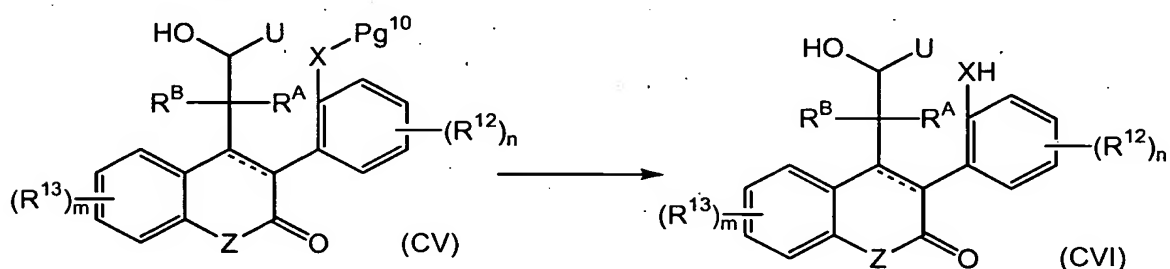


20 reacting a suitable substituted compound of formula (VIII), a known compound or compound prepared by known methods, wherein  $Pg^{10}$  is a protecting group, with an organic base selected from the group consisting of NaHMDS, LiHMDS, KHMDS, LDA and di(lower alkyl)amino lithium, to yield the

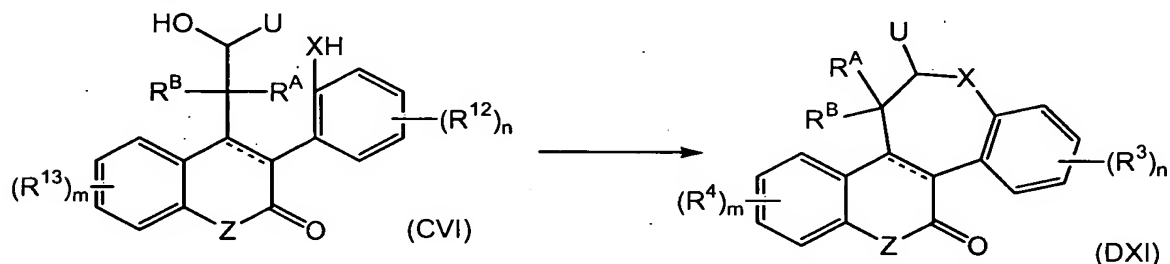
corresponding compound of formula (C), wherein V is the corresponding base cation;



reacting the compound of formula (C) with a suitably substituted  
 5 aldehyde, a compound of formula (CIV), to yield the corresponding compound of formula (CV);



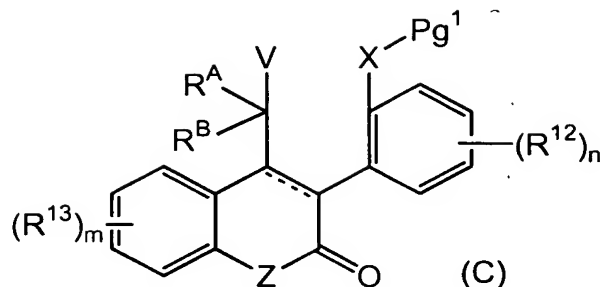
de-protecting the compound of formula (CV), to yield the corresponding compound of formula (CVI);



10

cyclizing the compound of formula (CVI), to yield the corresponding compound of formula (DXI).

The present invention is further directed to a process for the preparation  
 15 of a compound of formula (C)



wherein

==== represents a single or double bond,

X is selected from the group consisting of O and S;

5 Pg<sup>1</sup> is a protecting group selected from alkyl, allyl, benzyl, benzoyl, SEM, MOM, BOM and pivaloyl;

V is a base cation selected from the group consisting of Li, Na and K;

R<sup>A</sup> and R<sup>B</sup> are each independently selected from hydrogen, hydroxy, alkyl or alkoxy; provided that R<sup>A</sup> and R<sup>B</sup> are not each hydroxy;

10 Z is selected from the group consisting of O and S;

n is an integer from 0 to 4;

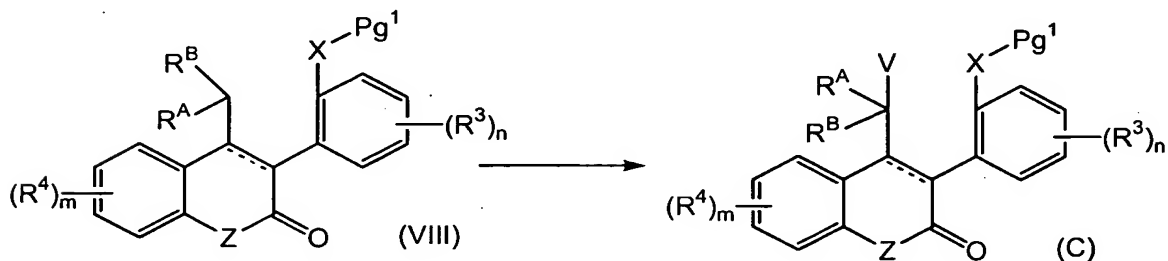
each R<sup>12</sup> is independently selected from the group consisting of halogen, hydroxy, alkyl, alkoxy, trialkylsilyl, acyloxy, benzoyloxy, aryloxy, aralkyloxy, SEMoxy, MOMoxy and pivaloyloxy;

15 m is an integer selected from 0 to 4;

each R<sup>13</sup> is independently selected from the group consisting of halogen, hydroxy, alkyl, alkoxy, trialkylsilyl, acyloxy, benzoyloxy, aryloxy, aralkyloxy, SEMoxy, MOMoxy and pivaloyloxy;

or a pharmaceutically acceptable salt thereof;

20 comprising



reacting a suitable substituted compound of formula (VIII), a known compound or compound prepared by known methods, wherein Pg<sup>1</sup> is as

defined above, with an organic base selected from the group consisting of LiHMDS, LDA, NaHMDS, KHMDS and di(lower alkyl)amino lithium, to yield the corresponding compound of formula (C).

5           The present invention is further directed to the product prepared according to any of the processes disclosed herein.

          Illustrative of the invention is a pharmaceutical composition comprising a pharmaceutically acceptable carrier and any of the compounds described  
10   above. An illustration of the invention is a pharmaceutical composition made by mixing any of the compounds described above and a pharmaceutically acceptable carrier. Illustrating the invention is a process for making a pharmaceutical composition comprising mixing any of the compounds described above and a pharmaceutically acceptable carrier.

15           Exemplifying the invention are methods of treating a disorder mediated by one or more estrogen receptors in a subject in need thereof comprising administering to the subject a therapeutically effective amount of any of the compounds or pharmaceutical compositions described above.

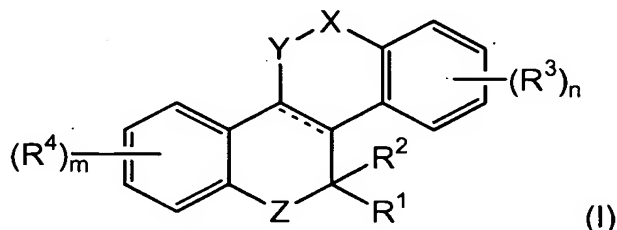
20           Illustrating the invention is a method of contraception comprising administering to a subject in need thereof co-therapy with a therapeutically effective amount of a compound of formula (I) with a progestogen or progestogen antagonist.

25           Another example of the invention is the use of any of the compounds described herein in the preparation of a medicament for treating: (a) hot flashes, (b) vaginal dryness, (c) osteopenia, (d) osteoporosis, (e) hyperlipidemia, (f) loss of cognitive function, (g) a degenerative brain disorder,  
30   (h) cardiovascular disease, (i) cerebrovascular disease (j) breast cancer, (k) endometrial cancer, (l) cervical cancer, (m) prostate cancer, (n) benign

prostatic hyperplasia, (o) endometriosis, (p) uterine fibroids, (q) osteoarthritis and for (r) contraception in a subject in need thereof.

### Detailed Description of the Invention

5 The present invention is directed to a compound of formula (I)



wherein  $\text{---}$ , X, Y, Z,  $R^1$ ,  $R^2$ , n,  $R^3$ , m, and  $R^4$  are as herein defined, useful for the treatment and / or prevention of disorders mediated by an estrogen receptor. More particularly, the compounds of the present invention  
 10 are useful for the treatment and / or prevention of disorders mediated by the estrogen- $\alpha$  and / or estrogen- $\beta$  receptors. More preferably, the compounds of the present invention are tissue selective estrogen receptor modulators.

The compounds of the present invention are further useful in the  
 15 treatment and / or prevention of disorders associated with the depletion of estrogen, hormone sensitive cancers and hyperplasia, endometriosis, uterine fibroids, osteoarthritis and as contraceptive agents, alone or in combination with a progestogen or progestogen antagonist.

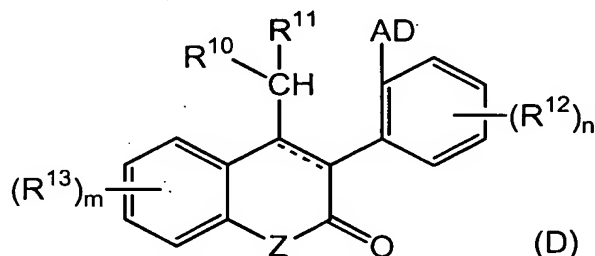
20 More particularly, the compounds of the present invention are useful in the treatment and / or prevention of a condition or disorder selected from the group consisting of hot flashes, vaginal dryness, osteopenia, osteoporosis, hyperlipidemia, loss of cognitive function, degenerative brain diseases, cardiovascular diseases, cerebrovascular diseases, cancer or hyperplasia of  
 25 the breast tissue, cancer or hyperplasia of the endometrium, cancer or hyperplasia of the cervix, cancer or hyperplasia of the prostate, endometriosis, uterine fibroids and osteoarthritis; and as a contraceptive agent. Preferably,

the disorder is selected from the group consisting of osteoporosis, hot flashes, vaginal dryness, breast cancer, and endometriosis.

In the compound of formula (I), the relative orientation of the groups R<sup>1</sup> and R<sup>2</sup> is not intended to be fixed, rather both possible orientations of the groups are intended to be included within the definition of the compound of formula (I).

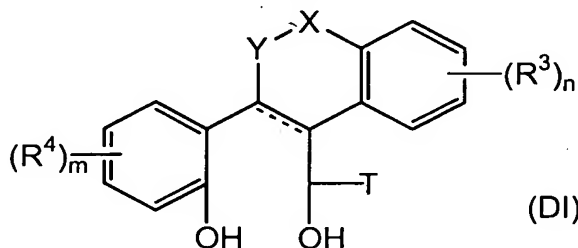
Wherein the compound of formula (I) Y is CR<sup>A</sup>R<sup>B</sup>C(O), the group is incorporated into the core structure such that the carbonyl portion of the group is bound to the X atom.

The present invention is further directed to compounds of formula (D).



wherein  $\text{---}$ , A, D, Z, R<sup>10</sup>, R<sup>11</sup>, n, R<sup>12</sup>, m and R<sup>13</sup> are as herein defined, useful as intermediates in the preparation of the compounds of formula (I).

The present invention is further directed to a compounds of formula (DI)



wherein  $\text{---}$ , X, Y, T, n, R<sup>3</sup>, m and R<sup>4</sup> are as herein defined, useful as intermediates in the preparation of the compounds of formula (I).

In an embodiment of the present invention is a compound of formula (I) wherein  $\text{---}$  represents a single or double bond,



X is selected from the group consisting of O and S and Y is selected from the group consisting of  $CR^A R^B$ ,  $CR^A R^B(CH_2)_{1-2}$ ,  $CR^A R^B C(O)$  and  $C(O)$ ; alternatively Y is selected from the group consisting of O and S and X is selected from the group consisting of  $CR^A R^B$  and  $C(O)$ ;

- 5 provided that when X is S, then Y is selected from the group consisting of  $CR^A R^B$  and  $CR^A R^B(CH_2)_{1-2}$ ; provided further that when Y is S, then X is selected from the group consisting of  $CR^A R^B$ ;

wherein each  $R^A$  and  $R^B$  is independently selected from hydrogen, hydroxy, alkyl or alkoxy; provided that  $R^A$  and  $R^B$  are not each hydroxy;

- 10 Z is selected from the group consisting of O and S;

- $R^1$  is selected from the group consisting of hydrogen, alkyl, cycloalkyl, aryl, aralkyl, heteroaryl and heteroaryl-alkyl; wherein the cycloalkyl, aryl, aralkyl, heteroaryl or heteroaryl-alkyl group is optionally substituted with one or more substituents independently selected from halogen, hydroxy, alkyl, alkoxy, 15 -SH, -S(alkyl),  $SO_2$ ,  $NO_2$ , CN,  $CO_2H$ ,  $R^C$ ,  $-OR^C$ ,  $-SO_2-NR^D R^E$ ,  $-NR^D R^E$ ,  $NR^D-SO_2-R^F$ ,  $-(alkyl)_{0-4}-C(O)NR^D R^E$ ,  $(alkyl)_{0-4}-NR^D-C(O)-R^F$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-NR^D R^E$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-C(O)-OR^F$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-C(O)-NR^D R^E$  or  $-(alkyl)_{0-4}-C(O)-(alkyl)_{0-4}-C(O)-OR^F$ ;

- wherein  $R^C$  is selected from the group consisting of alkyl, cycloalkyl, 20 cycloalkyl-alkyl, aryl, aralkyl, heteroaryl, heteroaryl-alkyl, heterocycloalkyl and heterocycloalkyl-alkyl; wherein the cycloalkyl, cycloalkyl-alkyl, aryl, aralkyl, heteroaryl, heteroaryl-alkyl, heterocycloalkyl or heterocycloalkyl-alkyl group is optionally substituted with one or more substituents independently selected from halogen, hydroxy, alkyl, alkoxy, -SH, -S(alkyl),  $SO_2$ ,  $NO_2$ , CN,  $CO_2H$ ,  $R^C$ , - 25  $SO_2-NR^D R^E$ ,  $NR^D R^E$ ,  $NR^D-SO_2-R^F$ ,  $-(alkyl)_{0-4}-C(O)-NR^D R^E$ ,  $-(alkyl)_{0-4}-NR^D-C(O)-R^F$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-NR^D R^E$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-C(O)-OR^F$ , -  $(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-C(O)-NR^D R^E$  or  $-(alkyl)_{0-4}-C(O)-(alkyl)_{0-4}-C(O)-OR^F$ ;

wherein Q is selected from the group consisting of O, S, NH, N(alkyl) and  $-CH=CH-$ ;

- 30 wherein  $R^D$  and  $R^E$  are each independently selected from the group consisting of hydrogen and alkyl; alternatively  $R^D$  and  $R^E$  are taken together with the nitrogen atom to which they are bound to form a 4 to 8 membered ring

selected from the group consisting of heteroaryl or heterocycloalkyl; wherein the heteroaryl or heterocycloalkyl group is optionally substituted with one or more substituents independently selected from halogen, hydroxy, alkyl, alkoxy, carboxy, amino, alkylamino, dialkylamino, nitro or cyano;

- 5            wherein  $R^F$  is selected from the group consisting of hydrogen, alkyl, cycloalkyl, cycloalkyl-alkyl, aryl, aralkyl, heteroaryl, heteroaryl-alkyl, heterocycloalkyl and heterocycloalkyl-alkyl; wherein the cycloalkyl, aryl, heteroaryl, heteroaryl-alkyl, heterocycloalkyl or heterocycloalkyl-alkyl group is optionally substituted with one or more substituents independently selected  
10        from halogen, hydroxy, alkyl, alkoxy, carboxy, amino, alkylamino, dialkylamino, nitro or cyano;

- $R^2$  is selected from the group consisting of hydroxy, alkyl, cycloalkyl, aryl, aralkyl, heteroaryl and heteroaryl-alkyl; wherein the cycloalkyl, aryl, aralkyl, heteroaryl or heteroaryl-alkyl group is optionally substituted with one or  
15        more substituents independently selected from halogen, hydroxy, alkyl, alkoxy, -SH, -S(alkyl),  $SO_2$ ,  $NO_2$ , CN,  $CO_2H$ ,  $R^C$ ,  $-OR^C$ ,  $-SO_2-NR^D R^E$ ,  $-NR^D R^E$ ,  $NR^D-SO_2-R^F$ ,  $-(alkyl)_{0-4}-C(O)NR^D R^E$ ,  $(alkyl)_{0-4}-NR^D-C(O)-R^F$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-NR^D R^E$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-C(O)-OR^F$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-C(O)-NR^D R^E$  or  $-(alkyl)_{0-4}-C(O)-(alkyl)_{0-4}-C(O)-OR^F$ ;

- 20            alternatively,  $R^1$  and  $R^2$  are taken together with the carbon atom to which they are bound to form  $C(O)$ ;

- provided that when  $R^1$  and  $R^2$  are taken together with the carbon atom to which they are bound to form  $C(O)$  and X is selected from the group consisting of O and S, then Y is selected from the group consisting of  $CR^A R^B$  and

- 25         $CR^A R^B(CH_2)_{1-2}$ ;

provided further that when  $R^1$  and  $R^2$  are taken together with the carbon atom to which they are bound to form  $C(O)$  and Y is selected from the group consisting of O and S, then X is selected from the group consisting of  $CR^A R^B$ ;

n is an integer selected from 0 to 4;

- 30            each  $R^3$  is independently selected from the group consisting of halogen, hydroxy,  $R^C$ , amino, alkylamino, dialkylamino, nitro, cyano,  $SO_2$ ,  $-C(O)R^G$ , -

$C(O)OR^G$ ,  $-OC(O)R^G$ ,  $-OC(O)OR^G$ ,  $-OC(O)N(R^G)_2$ ,  $-N(R^G)C(O)R^G$ ,  $-OSi(R^G)_3$ ,  $-OR^G$ ,  $-SO_2N(R^G)_2$ ,  $-O-(alkyl)_{1-4}-C(O)R^G$  and  $-O-(alkyl)_{1-4}-C(O)OR^G$ ;

wherein each  $R^G$  is independently selected from hydrogen, alkyl, aryl, aralkyl and 1,7,7-trimethyl-2-oxabicyclo[2.2.1]heptan-3-one; wherein the alkyl, aryl or aralkyl group is optionally substituted with one or more substituents independently selected from alkyl, halogenated alkyl, alkoxy, halogen, hydroxy, nitro, cyano,  $-OC(O)-alkyl$  or  $-C(O)O-alkyl$ ;

alternatively two  $R^G$  groups are taken together with the nitrogen atom to which they are bound to form a heterocycloalkyl group; wherein the heterocycloalkyl group is optionally substituted with one or more substituents independently selected from halogen, hydroxy, alkyl, alkoxy, carboxy, amino, alkylamino, dialkylamino, nitro or cyano;

m is an integer selected from 0 to 4;

each  $R^4$  is independently selected from the group consisting of halogen, hydroxy,  $R^C$ , amino, alkylamino, dialkylamino, nitro, cyano,  $SO_2$ ,  $-C(O)R^G$ ,  $-C(O)OR^G$ ,  $-OC(O)R^G$ ,  $-OC(O)OR^G$ ,  $-OC(O)N(R^G)_2$ ,  $-N(R^G)C(O)R^G$ ,  $-OSi(R^G)_3$ ,  $-OR^G$ ,  $-SO_2N(alkyl)_2$ ,  $-O-(alkyl)_{1-4}-C(O)R^G$  and  $-O-(alkyl)_{1-4}-C(O)OR^G$ ;

provided that when  $----$  is a double bond, X is  $CH_2$ , Y is O, Z is O and  $R^1$  and  $R^2$  are taken together with the carbon atom to which they are bound to form  $C(O)$ , then at least one of n or m is an integer selected from 1 to 4; preferably, n is an integer from 1 to 4 and m is an integer from 1 to 4;

provided further that when  $----$  is a single bond, X is O, Y is  $CH(alkyl)$ , Z is O,  $R^1$  is hydrogen and  $R^2$  is alkyl, then at least one of n or m is an integer selected from 1 to 4; preferably, n is an integer from 1 to 4 and m is an integer from 1 to 4;

provided further that when  $----$  is a single bond, X is O, Y is  $CH(alkyl)$ , Z is O,  $R^1$  is hydrogen,  $R^2$  is alkyl, n is 1 and m is 1, then  $R^3$  and  $R^4$  are other than methoxy or ethoxy, preferably  $R^3$  and  $R^4$  are other than alkoxy;

provided further that when  $----$  is a double bond, X is O, Y is  $CH_2$ , Z is O,  $R^1$  and  $R^2$  are taken together with the carbon atom to which they are bound to form  $C(O)$ , n is 0 and m is 2, then each  $R^4$  is not hydroxy or alkoxy.

or a pharmaceutically acceptable salt thereof.

In an embodiment of the present invention,  $\equiv$  represents a double bond.

5 In an embodiment of the present invention, when X is S, then Y is selected from the group consisting of  $CR^A R^B$ ,  $CR^A R^B(CH_2)_{1-2}$ ,  $CR^A R^B C(O)CR^A R^B$  (preferably  $CH=2C(O)CH_2$ ) and  $CH_2CH_2CH_2$ ; preferably Y is  $CR^A R^B$  or  $CR^A R^B(CH_2)_{1-2}$ . In another embodiment of the present invention, when Y is S, then X is  $CR^A R^B$ . In yet another embodiment of the present  
10 invention Y is selected from the group consisting of  $-CR^A R^B-CH_2-$ ,  $-CH_2CR^A R^BCH_2-$ ,  $-CR^A R^B-CH(OH)-CR^A R^B-$  and  $-CR^A R^B-CH_2-CR^A R^B-$ .

In an embodiment of the present invention  $\equiv$  represents a double bond; X is O; Z is O; and Y is selected from the group consisting of  $-CH_2-$ ,  $-CH_2CH_2-$ ,  $-CH_2CH_2CH_2-$ ,  $-CH(\text{lower alkoxy})-$ ,  $-CH(OH)-$ ,  $-CH(\text{lower alkyl})-$ ,  $-CH_2C(O)-$ ,  $-CH_2C(O)CH_2-$  and  $-CH_2CH(OH)CH_2-$ ; preferably Y is selected from the group consisting of  $-CH_2-$ ,  $-CH_2CH_2-$ ,  $-CH_2CH_2CH_2-$ ,  $-CH(OCH_3)-$ ,  $-CH(OH)-$ ,  $-CH((CH_2)_2CH_3)-$ ,  $-CH_2C(O)-$ ,  $-CH_2C(O)CH_2-$  and  $-CH_2CH(OH)CH_2-$ ; more  
15 preferably, Y is selected from the group consisting of  $-CH_2-$ ,  $-CH_2CH_2-$ ,  $-CH_2CH_2CH_2-$ ,  $-CH(OCH_3)-$  and  $-CH(OH)-$ ; more preferably still, Y is selected from the group consisting of  $-CH_2-$ ,  $-CH_2CH_2-$ ,  $-CH_2CH_2CH_2-$  and  $-CH(OH)-$ .

In another embodiment of the present invention  $\equiv$  represents a double bond; X is O; Z is O; and Y is selected from the group consisting of  $-CH_2-$ ,  $-CH_2CH_2-$ ,  $-CH(\text{lower alkoxy})-$ ,  $-CH(OH)-$ ,  $-CH(\text{lower alkyl})-$  and  $-CH_2C(O)-$ ; preferably Y is selected from the group consisting of  $-CH_2-$ ,  $-CH_2CH_2-$ ,  $-CH(OCH_3)-$ ,  $-CH(OH)-$ ,  $-CH((CH_2)_2CH_3)-$  and  $-CH_2C(O)-$ ; more  
25 preferably Y is selected from the group consisting of  $-CH_2-$ ,  $-CH(OCH_3)-$  and  $-CH(OH)-$ ; more preferably still Y is selected from the group consisting of  $-CH_2-$  and  $-CH(OH)-$ .

30

In an embodiment of the present invention are compounds of formula (I) wherein X is O, Y is  $CR^A R^B$  and Z is O. In another embodiment of the present

invention are compounds of formula (I) wherein X is  $CR^A R^B$ , Y is O and Z is O. In yet another embodiment of the present invention are compounds of formula (I) wherein X is O, Y is  $CR^A R^B C(O)$  and Z is O. In yet another embodiment of the present invention are compounds of formula (I) wherein X is O, Z is O and  
 5 Y is  $-CH_2C(O)CH_2-$ . In yet another embodiment of the present invention are compounds of formula (I) wherein X is O, Z is O and Y is selected from the group consisting of  $-CH_2-$ ,  $-CH_2CH_2-$  and  $-CH_2CH_2CH_2-$ .

10 In an embodiment of the present invention X is selected from the group consisting of O and S, preferably X is O. In another embodiment of the present invention Y is selected from the group consisting of O and S, preferably Y is O. Preferably Z is O.

15 In an embodiment of the present invention X is  $CR^A R^B$ . In another embodiment of the present invention Y is selected from the group consisting of  $CR^A R^B$ ,  $CR^A R^B CH_2$  and  $CR^A R^B C(O)$ .

20 In an embodiment of the present invention  $R^A$  and  $R^B$  are each independently selected from the group consisting of hydrogen, hydroxy, alkyl and alkoxy; provided that  $R^A$  and  $R^B$  are not each hydroxy. In a preferred embodiment of the present invention  $R^A$  and  $R^B$  are each independently selected from the group consisting of hydrogen hydroxy, isopropyl and methoxy; provided that both  $R^A$  and  $R^B$  are not hydroxy. In yet another embodiment of the present invention,  $R^A$  and  $R^B$  are each independently  
 25 selected from the group consisting of hydrogen, hydroxy and methoxy.

30 In an embodiment of the present invention,  $R^1$  is selected from the group consisting of hydrogen, lower alkyl, lower alkenyl, aryl,  $-C(O)$ -aryl, aralkyl, heteroaryl and heteroaryl-(lower alkyl); wherein the lower alkyl, aryl, aralkyl, heteroaryl or heteroaryl-(lower alkyl) group is optionally substituted with one to two substituents independently selected from halogen, hydroxy, lower alkyl, lower alkoxy,  $-SH$ ,  $-S$ (lower alkyl),  $SO_2$ ,  $NO_2$ ,  $CN$ ,  $-C(O)$ -(lower alkyl),  $CO_2H$ ,

$R^C$ ,  $-\text{SO}_2-\text{NR}^D\text{R}^E$ ,  $-\text{NR}^D\text{R}^E$ ,  $\text{NR}^D-\text{SO}_2-\text{R}^F$ ,  $-(\text{alkyl})_{0-4}-\text{C}(\text{O})\text{NR}^D\text{R}^E$ ,  $-\text{C}(\text{O})\text{O}-(\text{lower alkyl})-\text{NR}^D\text{R}^E$ ,  $-\text{C}(\text{O})-\text{NH}-(\text{lower alkyl})-\text{NR}^D\text{R}^E$ ,  $-\text{C}(\text{O})-(\text{N containing heterocycloalkyl (wherein said N containing heterocycloalkyl is bound through the N atom)})-\text{NR}^D\text{R}^E$ ,  $-\text{C}(\text{O})-(\text{N containing heterocycloalkyl (wherein said N containing heterocycloalkyl is bound through the N atom)})-\text{R}^F$ ,  $-(\text{alkyl})_{0-4}-\text{NR}^D-\text{C}(\text{O})-\text{R}^F$ ,  $-(\text{alkyl})_{0-4}-(\text{Q})_{0-1}-(\text{alkyl})_{0-4}-\text{NR}^D\text{R}^E$ ,  $-(\text{alkyl})_{0-4}-(\text{Q})_{0-1}-(\text{alkyl})_{0-4}-\text{C}(\text{O})-\text{OR}^F$ ,  $-(\text{alkyl})_{0-4}-(\text{Q})_{0-1}-(\text{alkyl})_{0-4}-\text{C}(\text{O})-\text{NR}^D\text{R}^E$ ,  $-(\text{alkyl})_{0-4}-\text{C}(\text{O})-(\text{alkyl})_{0-4}-\text{C}(\text{O})-\text{OR}^F$ ,  $-\text{O}-(\text{lower alkyl})-\text{OSi}(\text{lower alkyl})_3$ ,  $-\text{O}-(\text{lower alkyl})-\text{OR}^D$  or  $-\text{O}-(\text{lower alkyl})-\text{formyl}$ .

In another embodiment of the present invention  $R^1$  is selected from the group consisting of hydrogen and lower alkyl, preferably  $R^1$  is selected from the group consisting of hydrogen and methyl. In another embodiment of the present invention,  $R^1$  is hydrogen.

In an embodiment of the present invention  $R^1$  is hydrogen and  $R^2$  is in the R stereo-configuration. In another embodiment of the present invention  $R^1$  is hydrogen and  $R^2$  is in the S stereo-configuration.

In an embodiment of the present invention  $R^1$  is selected from the group consisting of hydrogen, lower alkyl, aryl, aralkyl, heteroaryl and heteroaryl-(lower alkyl); wherein the aryl, aralkyl, heteroaryl or heteroaryl-(lower alkyl) group is optionally substituted with one to two substituents independently selected from halogen, hydroxy, lower alkyl, lower alkoxy,  $-\text{SH}$ ,  $-\text{S}(\text{lower alkyl})$ ,  $\text{SO}_2$ ,  $\text{NO}_2$ ,  $\text{CN}$ ,  $\text{CO}_2\text{H}$ ,  $R^C$ ,  $-\text{SO}_2-\text{NR}^D\text{R}^E$ ,  $-\text{NR}^D\text{R}^E$ ,  $\text{NR}^D-\text{SO}_2-\text{R}^F$ ,  $-(\text{alkyl})_{0-4}-\text{C}(\text{O})\text{NR}^D\text{R}^E$ ,  $(\text{alkyl})_{0-4}-\text{NR}^D-\text{C}(\text{O})-\text{R}^F$ ,  $-(\text{alkyl})_{0-4}-(\text{Q})_{0-1}-(\text{alkyl})_{0-4}-\text{NR}^D\text{R}^E$ ,  $-(\text{alkyl})_{0-4}-(\text{Q})_{0-1}-(\text{alkyl})_{0-4}-\text{C}(\text{O})-\text{OR}^F$ ,  $-(\text{alkyl})_{0-4}-(\text{Q})_{0-1}-(\text{alkyl})_{0-4}-\text{C}(\text{O})-\text{NR}^D\text{R}^E$  or  $-(\text{alkyl})_{0-4}-\text{C}(\text{O})-(\text{alkyl})_{0-4}-\text{C}(\text{O})-\text{OR}^F$ .

Preferably  $R^1$  is selected from the group consisting of hydrogen, lower alkyl, aryl, aralkyl, heteroaryl and heteroaryl-(lower alkyl); wherein the aryl, aralkyl, heteroaryl or heteroaryl-(lower alkyl) group is optionally substituted with one to two substituents independently selected from halogen, hydroxy, lower alkyl, lower alkoxy,  $-\text{SH}$ ,  $-\text{S}(\text{lower alkyl})$ ,  $\text{SO}_2$ ,  $\text{NO}_2$ ,  $\text{CN}$ ,  $\text{CO}_2\text{H}$ ,  $R^C$  or  $\text{NR}^D\text{R}^E$ ,

More preferably,  $R^1$  is selected from the group consisting of hydrogen and lower alkyl. More preferably still,  $R^1$  is selected from the group consisting of hydrogen and methyl.

5 In an embodiment of the present invention  $R^C$  is selected from the group consisting of lower alkyl, aryl, aralkyl, heteroaryl, heteroaryl-(lower alkyl), heterocycloalkyl and heterocycloalkyl-(lower alkyl); wherein the aryl, aralkyl, heteroaryl, heteroaryl-(lower alkyl), heterocycloalkyl or heterocycloalkyl-(lower alkyl) group is optionally substituted with one to two substituents independently  
10 selected from halogen, hydroxy, lower alkyl, lower alkoxy, -SH, -S(alkyl),  $SO_2$ ,  $NO_2$ , CN,  $CO_2H$ ,  $R^C$ ,  $-SO_2-NR^D R^E$ ,  $NR^D-SO_2-R^F$ ,  $-(alkyl)_{0-4}-C(O)-NR^D R^E$ ,  $-(alkyl)_{0-4}-NR^D-C(O)-R^F$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-NR^D R^E$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-C(O)-OR^F$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-C(O)-NR^D R^E$  or  $-(alkyl)_{0-4}-C(O)-$   
15  $(alkyl)_{0-4}-C(O)-OR^F$ .

15 Preferably,  $R^C$  is selected from the group consisting of lower alkyl, aryl, aralkyl, heteroaryl, heteroaryl-(lower alkyl), heterocycloalkyl and heterocycloalkyl-(lower alkyl); wherein the aryl, aralkyl, heteroaryl, heteroaryl-(lower alkyl), heterocycloalkyl or heterocycloalkyl-(lower alkyl) group is optionally substituted with one to two substituents independently selected from  
20 halogen, hydroxy, lower alkyl, lower alkoxy, -SH, -S(alkyl),  $SO_2$ ,  $NO_2$ , CN,  $CO_2H$ ,  $R^C$  or  $NR^D R^E$ .

More preferably  $R^C$  is selected from the group consisting of lower alkyl, and aralkyl. More preferably still,  $R^C$  is selected from the group consisting of methyl, isopropyl and benzyl.

25

In an embodiment of the present invention, Q is selected from the group consisting of O, S and  $-CH=CH-$ . Preferably, Q is selected from the group consisting of O and  $-CH=CH-$ , more preferably, Q is O.

30 In an embodiment of the present invention  $R^D$  and  $R^E$  are each independently selected from the group consisting of hydrogen and lower alkyl. In another embodiment of the present invention,  $R^D$  and  $R^E$  are taken together

with the nitrogen atom to which they are bound to form a 4 to 8 membered ring selected from the group consisting of heteroaryl or heterocycloalkyl; wherein the heteroaryl or heterocycloalkyl group is optionally substituted with one to two substituents independently selected from halogen, hydroxy, lower alkyl, lower alkoxy, carboxy, amino, (lower alkyl)-amino, di(lower alkyl)amino, nitro or cyano. In another embodiment of the present invention,  $R^D$  and  $R^E$  are taken together with the nitrogen atom to which they are bound to form a 5 to 6 membered ring selected from the group consisting of heteroaryl or heterocycloalkyl; wherein the heteroaryl or heterocycloalkyl group is optionally substituted with one to two substituents independently selected from halogen, hydroxy, lower alkyl, lower alkoxy, carboxy, amino, (lower alkyl)-amino, di(lower alkyl)amino, nitro or cyano.

In another embodiment of the present invention,  $R^D$  and  $R^E$  are each independently selected from the group consisting of hydrogen, methyl, ethyl and isopropyl.

In another embodiment of the present invention,  $R^D$  and  $R^E$  are taken together with the nitrogen atom to which they are bound to form a 5 to 6 membered ring selected from the group consisting of heteroaryl or heterocycloalkyl; wherein the heteroaryl or heterocycloalkyl group is optionally substituted with one to two substituents independently selected from halogen, hydroxy, oxo, lower alkyl, lower alkoxy, carboxy, amino, (lower alkyl)-amino, di(lower alkyl)amino, nitro or cyano. Preferably,  $R^D$  and  $R^E$  are taken together with the nitrogen atom to which they are bound to form a 5 to 6 membered ring selected from the group consisting of azepanyl, morpholinyl, pyridyl, piperidinyl, piperazinyl, pyrrolidinyl, piperidinyl-2,6-dione and pyrrolidinyl-2,5-dione.

In an embodiment of the present invention  $R^F$  is selected from the group consisting of hydrogen, lower alkyl, aryl, aralkyl, heteroaryl, heteroaryl-(lower alkyl), heterocycloalkyl and heterocycloalkyl-(lower alkyl); wherein the aryl, heteroaryl, heteroaryl-(lower alkyl), heterocycloalkyl or heterocycloalkyl-(lower alkyl) group is optionally substituted with one to two substituents independently selected from halogen, hydroxy, lower alkyl, lower alkoxy, carboxy, amino,



(lower alkyl)-amino, di(lower alkyl)amino, nitro or cyano. Preferably  $R^F$  is selected from the group consisting of hydrogen, lower alkyl, aryl and heteroaryl; wherein the aryl is optionally substituted with a halogen. More preferably,  $R^F$  is selected from the group consisting of hydrogen, methyl, 4-fluorophenyl and 2-pyridyl.

In an embodiment of the present invention  $R^2$  is selected from the group consisting of hydroxy, lower alkyl, aryl, aralkyl, heteroaryl and heteroaryl-(lower alkyl); wherein the aryl, aralkyl, heteroaryl or heteroaryl-(lower alkyl) group is optionally substituted with one to two substituents independently selected from halogen, hydroxy, lower alkyl, lower alkoxy, -SH, -S(lower alkyl),  $SO_2$ ,  $NO_2$ , CN,  $CO_2H$ ,  $R^C$ ,  $-OR^C$ ,  $-SO_2-NR^D R^E$ ,  $-NR^D R^E$ ,  $-(alkyl)_{0-4}-C(O)NR^D R^E$ ,  $(alkyl)_{0-4}-NR^D-C(O)-R^F$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-NR^D R^E$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-C(O)-OR^F$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-C(O)-NR^D R^E$  or  $-(alkyl)_{0-4}-C(O)-(alkyl)_{0-4}-C(O)-OR^F$ .

Preferably,  $R^2$  is selected from the group consisting of hydroxy, lower alkyl, aryl, aralkyl, heteroaryl and heteroaryl-(lower alkyl); wherein the aryl, aralkyl, heteroaryl or heteroaryl-(lower alkyl) group is optionally substituted with one to two substituents independently selected from halogen, hydroxy, lower alkyl, lower alkoxy, -SH, -S(lower alkyl),  $SO_2$ ,  $NO_2$ , CN,  $CO_2H$ ,  $R^C$ ,  $-OR^C$  or  $-NR^D R^E$ .

More preferably,  $R^2$  is selected from the group consisting of hydroxy, aryl, 4-(1-heterocycloalkyl-alkoxy)-phenyl, 4-(di(alkyl)amino-alkoxy)-phenyl, 4-(di(alkyl)amino)-phenyl and 4-aralkyloxy-phenyl. More preferably still,  $R^2$  is selected from the group consisting of hydroxy, phenyl, 4-(1-piperidinyl-ethoxy)-phenyl, 4-(1-pyrrolidinyl-ethoxy)-phenyl, 4-(4-morpholinyl-ethoxy)-phenyl, 4-(1-azepanyl-ethoxy)-phenyl, 4-(diethylamino-ethoxy)-phenyl, 4-(dimethylamino-ethoxy)-phenyl, 4-(dimethylamino)-phenyl, 4-benzyloxy-phenyl and 4-(1-piperidinyl-n-propoxy)-phenyl. More preferably still,  $R^2$  is selected from the group consisting of phenyl, 4-(1-piperidinyl-ethoxy)-phenyl, 4-(1-pyrrolidinyl-ethoxy)-phenyl, 4-(4-morpholinyl-ethoxy)-phenyl, 4-(1-azepanyl-ethoxy)-phenyl, 4-(diethylamino-ethoxy)-phenyl, 4-(dimethylamino-ethoxy)-phenyl, 4-(dimethylamino)-phenyl and 4-(1-piperidinyl-n-propoxy)-phenyl. More

preferably still,  $R^2$  is selected from the group consisting of phenyl, 4-(1-piperidinyl-ethoxy)-phenyl, 4-(1-pyrrolidinyl-ethoxy)-phenyl, 4-(4-morpholinyl-ethoxy)-phenyl, 4-(1-azepanyl-ethoxy)-phenyl, 4-(diethylamino-ethoxy)-phenyl, 4-(dimethylamino-ethoxy)-phenyl and 4-(dimethylamino)-phenyl. More

5 preferably still,  $R^2$  is selected from the group consisting of phenyl, 4-(1-piperidinyl-ethoxy)-phenyl, 4-(1-pyrrolidinyl-ethoxy)-phenyl, 4-(4-morpholinyl-ethoxy)-phenyl, 4-(1-azepanyl-ethoxy)-phenyl, 4-(dimethylamino-ethoxy)-phenyl and 4-(dimethylamino)-phenyl.

10 In another embodiment of the present invention  $R^2$  is selected from the group consisting of  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-NR^D R^E$  and  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-C(O)OR^F$ . In yet another embodiment of the present invention,  $R^2$  is selected from the group consisting of  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-NR^D R^E$ ; wherein  $R^D$  and  $R^E$  are taken together with the nitrogen atom to which they are bound to

15 form a 5 to 7 membered ring selected from the group consisting of heteroaryl and heterocycloalkyl.

In yet another embodiment of the present invention,  $R^2$  is selected from the group consisting of hydroxy, lower alkyl, lower alkenyl, aryl,  $-C(O)$ -aryl, 20 aralkyl, heteroaryl and heteroaryl-(lower alkyl); wherein the lower alkyl, aryl, aralkyl, heteroaryl or heteroaryl-(lower alkyl) group is optionally substituted with one to two substituents independently selected from halogen, hydroxy, lower alkyl, lower alkoxy,  $-SH$ ,  $-S$ (lower alkyl),  $SO_2$ ,  $NO_2$ ,  $CN$ ,  $-C(O)$ -(lower alkyl),  $CO_2H$ ,  $R^C$ ,  $-OR^C$ ,  $-SO_2-NR^D R^E$ ,  $-NR^D R^E$ ,  $-(alkyl)_{0-4}-C(O)NR^D R^E$ ,  $-C(O)O$ -(lower

25 alkyl)- $NR^D R^E$ ,  $-C(O)-NH$ -(lower alkyl)- $NR^D R^E$ ,  $-C(O)$ -(N containing heterocycloalkyl (wherein said N containing heterocycloalkyl is bound through the N atom))- $NR^D R^E$ ,  $-C(O)$ -(N containing heterocycloalkyl, bound through the N atom)- $R^F$ ,  $(alkyl)_{0-4}-NR^D-C(O)-R^F$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-NR^D R^E$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-C(O)-OR^F$ ,  $-(alkyl)_{0-4}-(Q)_{0-1}-(alkyl)_{0-4}-C(O)-NR^D R^E$ ,  $-(alkyl)_{0-4}-C(O)-(alkyl)_{0-4}-C(O)-OR^F$ ,  $-O$ -(lower alkyl)- $OSi$ (lower alkyl)<sub>3</sub>,  $-O$ -(lower alkyl)- $OR^D$  or  $-O$ -(lower alkyl)-formyl.

30

Preferably,  $R^2$  is selected from the group consisting of hydroxy, lower alkenyl, carboxy-lower alkyl, hydroxy-lower alkyl, aryl, 4-(1-N containing heterocycloalkyl (wherein said N containing heterocycloalkyl is bound through the N atom)-alkoxy)-phenyl, 4-(di(lower alkyl)amino-alkoxy)-phenyl, 4-(di(lower alkyl)amino)-phenyl, 4-alkoxy-phenyl, lower alkoxy-carbonyl-lower alkyl, 4-(lower alkoxy-lower alkoxy)-phenyl, di(lower alkyl)amino-(lower alkoxy)-carbonyl-(lower alkyl), (N containing heterocycloalkyl (wherein said N containing heterocycloalkyl is bound through the N atom))-(lower alkoxy)-carbonyl-(lower alkyl), (N containing heterocycloalkyl (wherein said N containing heterocycloalkyl is bound through the N atom))-(lower alkyl)-amino-carbonyl-(lower alkyl), (N containing heteroaryl)-(N containing heterocycloalkyl (wherein said N containing heterocycloalkyl is bound through the N atom))-C(O)-(lower alkyl), (halo-substituted aryl)-(N containing heterocycloalkyl (wherein said N containing heterocycloalkyl is bound through the N atom))-carboxy-(lower alkyl), 4-((N containing heterocycloalkyl)-(lower alkoxy))-phenyl-carbonyl, 2-hydroxy-2-(4-N containing heterocycloalkyl-lower alkoxy)-phenyl-ethyl, 4-(tri(lower alkyl)silyloxy-(lower alkoxy)-phenyl, 4-(hydroxy-lower alkoxy)-phenyl, 4-(formyl-lower alkoxy)-phenyl, 4-(carboxy-lower alkoxy)-phenyl, 4-(lower alkoxy-carbonyl-lower alkoxy)-phenyl, 4-(piperidinyl-2,6-dione-lower alkoxy)-phenyl, 4-(pyrrolidinyl-2,5-dione-(lower alkyl)-phenyl, R-4-(pyrrolidinyl-2,5-dione-(lower alkoxy)-phenyl and S-4-(pyrrolidinyl-2,5-dione-(lower alkoxy)-phenyl.

More preferably,  $R^2$  is selected from the group consisting of hydroxy, allyl, carboxymethyl, hydroxy-ethyl, 3-hydroxy-n-propyl, phenyl, 3-(1-piperidinyl-ethoxy)-phenyl, 4-(1-piperidinyl-ethoxy)-phenyl, S-4-(piperidinyl-ethoxy)-phenyl, R-4-(piperidinyl-ethoxy)-phenyl, 4-(1-pyrrolidinyl-ethoxy)-phenyl, 4-(4-morpholinyl-ethoxy)-phenyl, 4-(1-azepanyl-ethoxy)-phenyl, R-4-(1-azepanyl-ethoxy)-phenyl, S-4-(1-azepanyl-ethoxy)-phenyl, 4-(diethylamino-ethoxy)-phenyl, 4-(dimethylamino-ethoxy)-phenyl, R-4-(dimethylamino-ethoxy)-phenyl, S-4-(dimethylamino-ethoxy)-phenyl, 4-(diisopropylamino-ethoxy)-phenyl, R-4-(diisopropylamino-ethoxy)-phenyl, S-4-(diisopropylamino-ethoxy)-phenyl, 4-(dimethylamino)-phenyl, 4-benzyloxy-phenyl, 4-(1-piperidinyl-n-propoxy)-phenyl, 4-(t-butyl-dimethyl-silyloxy-ethoxy)-phenyl, 4-(methoxy-ethoxy)-phenyl,

methoxy-carbonyl-methyl, isopropoxy-carbonyl-methyl, dimethylamino-ethoxy-carbonyl-methyl, piperidinyl-ethoxy-carbonyl-methyl, pyrrolidinyl-ethoxy-carbonyl-methyl, morpholinyl-ethoxy-carbonyl-methyl, dimethylamino-n-propoxy-carbonyl-methyl and morpholinyl-ethyl-amino-carbonyl-methyl,

5 morpholinyl-n-propyl-amino-carbonyl-methyl, pyrrolidinyl-ethyl-amino-carbonyl-methyl, 4-(2-pyridyl)-piperazinyl-carbonyl-methyl, 4-(4-fluorophenyl)-piperazinyl-carboxy-methyl, 4-(piperidinyl-ethoxy)-phenyl-carbonyl, 2-hydroxy-2-(4-(piperidinyl-ethoxy)-phenyl)-ethyl, 4-(2-hydroxy-ethoxy)-phenyl, R-4-(2-hydroxy-ethoxy)-phenyl, S-4-(hydroxy-ethoxy)-phenyl, 4-(3-hydroxy-n-propoxy)-phenyl, R-4-(3-hydroxy-n-propoxy)-phenyl, S-4-(3-hydroxy-n-propoxy)-phenyl,

10 4-(formyl-methoxy)-phenyl, 4-(carboxy-methoxy)-phenyl, 4-carboxy-ethoxy-phenyl, 4-(methoxy-carbonyl-methoxy)-phenyl, 4-(methoxy-carbonyl-ethoxy)-phenyl, R-4-(piperidinyl-2,6-dione-ethoxy)-phenyl, R-4-(pyrrolidinyl-2,5-dione-ethoxy)-phenyl, S-4-(pyrrolidinyl-2,5-dione-ethoxy)-phenyl, R-4-(pyrrolidinyl-2,5-dione-n-propoxy)-phenyl and S-4-(pyrrolidinyl-2,5-dione-n-propoxy)-phenyl.

15

More preferably still, R<sup>2</sup> is selected from the group consisting of phenyl, 4-(1-piperidinyl-ethoxy)-phenyl, R-4(piperidinyl-ethoxy)-phenyl, S-4-(piperidinyl-ethoxy)-phenyl, 4-(1-pyrrolidinyl-ethoxy)-phenyl, 4-(4-morpholinyl-ethoxy)-phenyl, 4-(1-azepanyl-ethoxy)-phenyl, R-4-(azepanyl-ethoxy)-phenyl, S-4-

20 (azepanyl-ethoxy)-phenyl, 4-(diethylamino-ethoxy)-phenyl, 4-(dimethylamino-ethoxy)-phenyl, R-4-(dimethylamino-ethoxy)-phenyl, S-4-(dimethylamino-ethoxy)-phenyl, R-4-(diisopropylamino-ethoxy)-phenyl, S-4-(diisopropylamino-ethoxy)-phenyl, 4-(dimethylamino)-phenyl, 4-(3-hydroxy-n-propoxy)-phenyl and 4-(methoxy-carbonyl-methoxy).

25 More preferably still, R<sup>2</sup> is selected from the group consisting of phenyl, 4-(1-piperidinyl-ethoxy)-phenyl, R-4-(piperidinyl-ethoxy)-phenyl, S-4-(piperidinyl-ethoxy)-phenyl, 4-(1-pyrrolidinyl-ethoxy)-phenyl, 4-(4-morpholinyl-ethoxy)-phenyl, 4-(1-azepanyl-ethoxy)-phenyl, R-4-(azepanyl-ethoxy)-phenyl, S-4-(azepanyl-ethoxy)-phenyl, 4-(diethylamino-ethoxy)-phenyl, 4-

30 (dimethylamino-ethoxy)-phenyl, R-4-(dimethylamino-ethoxy)-phenyl, S-4-(dimethylamino-ethoxy)-phenyl, R-4-(diisopropylamino-ethoxy)-phenyl, S-4-

(diisopropylamino-ethoxy)-phenyl, 4-(dimethylamino)-phenyl, 4-(3-hydroxy-n-propoxy)-phenyl and 4-(methoxy-carbonyl-methoxy).

More preferably still,  $R^2$  is selected from the group consisting of phenyl, 4-(1-piperidinyl-ethoxy)-phenyl, R-4-(piperidinyl-ethoxy)-phenyl, S-4-(piperidinyl-ethoxy)-phenyl, 4-(1-pyrrolidinyl-ethoxy)-phenyl, 4-(4-morpholinyl-ethoxy)-phenyl, 4-(1-azepanyl-ethoxy)-phenyl, R-4-(azepanyl-ethoxy)-phenyl, S-4-(azepanyl-ethoxy)-phenyl, 4-(dimethylamino-ethoxy)-phenyl, R-4-(dimethylamino-ethoxy)-phenyl, S-4-(dimethylamino-ethoxy)-phenyl, R-4-(diisopropylamino-ethoxy)-phenyl, S-4-(diisopropylamino-ethoxy)-phenyl, 4-(dimethylamino)-phenyl, 4-(3-hydroxy-n-propoxy)-phenyl and 4-(methoxy-carbonyl-methoxy).

In yet another embodiment of the present invention  $R^2$  is selected from the group consisting of aryl substituted with  $-O-(alkyl)-NR^D R^E$ .

15

In an embodiment of the present invention are compounds of formula (I) wherein  $R^1$  and  $R^2$  are taken together with the carbon atom to which they are bound to form  $C(O)$ .

In another embodiment of the present invention,  $R^1$  and  $R^2$  are taken together with the carbon atom to which they are bound to form  $C(O)$  and Y is selected from the group consisting of  $CR^A R^B$ ,  $CR^A R^B (CH_2)_{1-2}$ ,  $CR^A R^B C(O)$ ,  $CH_2 C(O) CH_2$  and  $CH_2 CR^A R^B CH_2$ , preferably  $CR^A R^B$ ,  $CR^A R^B (CH_2)_{1-2}$ ,  $CR^A R^B C(O)$  and  $CH_2 C(O) CH_2$ . More preferably,  $R^1$  and  $R^2$  are taken together with the carbon atom to which they are bound to form  $C(O)$  and Y is selected from the group consisting of  $CH_2$ ,  $CH_2 CH_2$ ,  $CH_2 CH_2 CH_2$ ,  $CH_2 C(O)$  and  $CH_2 C(O) CH_2$ .

In an embodiment of the present invention, n is an integer selected from 0 to 2. Preferably, n is an integer selected from 0 to 1. In another embodiment of the present invention, n is 1.

30

In an embodiment of the present invention, an  $R^3$  substituent is bound at the 2-position of the core ring structure.

In an embodiment of the present invention  $R^3$  is selected from the group  
 5 consisting of halogen, hydroxy,  $R^C$ , amino, (lower alkyl)-amino, di(lower alkyl)amino, nitro, cyano,  $-OC(O)R^G$ ,  $-OC(O)OR^G$ ,  $-OC(O)N(R^G)_2$ ,  $-OSi(R^G)_3$ ,  $-OR^G$ ,  $-O-(alkyl)_{1-4}-C(O)R^G$  and  $-O-(alkyl)_{1-4}-C(O)OR^G$ .

Preferably,  $R^3$  is selected from the group consisting of hydroxy,  $R^C$ ,  $-OC(O)R^G$ ,  $-OC(O)OR^G$ ,  $-OC(O)N(R^G)_2$ ,  $-OSi(R^G)_3$ ,  $-OR^G$ ,  $-O-(alkyl)_{1-4}-C(O)R^G$   
 10 and  $-O-(alkyl)_{1-4}-C(O)OR^G$ .

More preferably,  $R^3$  is selected from the group consisting of halogen, hydroxy, lower alkoxy, tri(lower alkyl)-silyloxy,  $-OC(O)-(lower\ alkyl)$ ,  $-OC(O)-C(phenyl)-OC(O)-(lower\ alkyl)$ ,  $-OC(O)-(1,7,7-trimethyl-2-oxabicyclo[2.2.1]heptan-3-one)$  and  $-OC(O)-C(CH_3)(CF_3)-phenyl$ . More  
 15 preferably still  $R^3$  is selected from the group consisting of fluoro, hydroxy, methoxy, t-butyl-dimethyl-silyloxy,  $-OC(O)-methyl$ ,  $-OC(O)-t-butyl$ ,  $-OC(O)-C(phenyl)-OC(O)CH_3$ ,  $-OC(O)-(1,7,7-trimethyl-2-oxabicyclo[2.1]heptan-3-one)$  and  $-OC(O)-C(CH_3)(CF_3)-phenyl$ . More preferably still,  $R^3$  is selected from the group consisting of hydroxy, methoxy and  $-OC(O)-t-butyl$ . More preferably still,  
 20  $R^3$  is selected from the group consisting of hydroxy and  $-OC(O)-t-butyl$ .

In an embodiment of the present invention  $R^G$  is selected from hydrogen, lower alkyl (preferably methyl), aryl, aralkyl and 1,7,7-trimethyl-2-oxabicyclo[2.2.1]heptan-3-one; wherein the alkyl, aryl or aralkyl group is  
 25 optionally substituted with one to two substituents independently selected from lower alkyl, halogenated lower alkyl, lower alkoxy, halogen, hydroxy, nitro, cyano,  $-OC(O)-(lower\ alkyl)$  and  $-C(O)O-(lower\ alkyl)$ .

In another embodiment of the present invention two  $R^G$  groups are taken together with the nitrogen atom to which they are bound to form a 5 to 6  
 30 membered heterocycloalkyl group; wherein the heterocycloalkyl group is optionally substituted with one to two substituents independently selected from

halogen, hydroxy, lower alkyl, lower alkoxy, carboxy, amino, (lower alkyl)-amino, di(lower alkyl)amino, nitro or cyano.

Preferably,  $R^G$  is selected from the group consisting of lower alkyl, aralkyl and 1,7,7-trimethyl-2-oxabicyclo[2.2.1]heptan-3-one; wherein the aralkyl group is optionally substituted with lower alkyl, halogenated alkyl or  $-OC(O)$ -(lower alkyl). More preferably,  $R^G$  is selected from the group consisting of methyl, t-butyl,  $-C(CH_3)(CF_3)$ -phenyl,  $-CH(OC(O)CH_3)$ -phenyl and 1,7,7-trimethyl-2-oxabicyclo[2.2.1]heptan-3-one.

10 In an embodiment of the present invention, m is an integer selected from 0 to 2. Preferably, m is an integer selected from 0 to 1. In another embodiment of the present invention, m is 1.

15 In an embodiment of the present invention, an  $R^4$  substituent is bound at the 8- or 9- position of the core ring structure.

In an embodiment of the present invention  $R^4$  is selected from the group consisting of halogen, hydroxy,  $R^C$ , amino, (lower alkyl)-amino, di(lower alkyl)amino, nitro, cyano,  $-OC(O)R^G$ ,  $-OC(O)OR^G$ ,  $-OC(O)N(R^G)_2$ ,  $-OSi(R^G)_3$ ,  $-OR^G$ ,  $-O-(alkyl)_{1-4}-C(O)R^G$  and  $-O-(alkyl)_{1-4}-C(O)OR^G$ .

Preferably  $R^4$  is selected from the group consisting of hydroxy,  $R^C$ ,  $-OC(O)R^G$ ,  $-OC(O)OR^G$ ,  $-OC(O)N(R^G)_2$ ,  $-OSi(R^G)_3$ ,  $-OR^G$ ,  $-O-(alkyl)_{1-4}-C(O)R^G$  and  $-O-(alkyl)_{1-4}-C(O)OR^G$ .

More preferably,  $R^4$  is selected from the group consisting of hydroxy, lower alkyl, lower alkoxy, tri(lower alkyl)-silyloxy,  $-OC(O)$ -(lower alkyl),  $-OC(O)$ -C(phenyl)- $OC(O)$ -(lower alkyl),  $-OC(O)$ -(1,7,7-trimethyl-2-oxabicyclo[2.2.1]heptan-3-one) and  $-OC(O)$ - $C(CH_3)(CF_3)$ -phenyl. More preferably still,  $R^4$  is selected from the group consisting of hydroxy, methyl, methoxy, t-butyl-dimethyl-silyloxy,  $-OC(O)$ -methyl,  $-OC(O)$ -t-butyl,  $-OC(O)$ -C(phenyl)- $OC(O)CH_3$ ,  $-OC(O)$ -(1,7,7-trimethyl-2-oxabicyclo[2.1]heptan-3-one) and  $-OC(O)$ - $C(CH_3)(CF_3)$ -phenyl. More preferably still,  $R^4$  is selected from the group consisting of fluoro, hydroxy, methoxy and  $-OC(O)$ -t-butyl. More

preferably still,  $R^4$  is selected from the group consisting of hydroxy and  $-OC(O)-t\text{-butyl}$ .

In an embodiment of the present invention  $\equiv$  represents a single or  
5 double bond,

X is selected from the group consisting of O and S and Y is selected from the group consisting of  $CR^A R^B$ ,  $CR^A R^B(R^A R^B)_{1-2}$ , (preferably  $CR^A R^B(CR^A R^B)_{1-2}$  is selected from  $-CR^A R^B(CH_2)_{1-2}$ ,  $-CH_2CR^A R^BCH_2-$ ,  $-CR^A R^B-CH(OH)-CR^A R^B-$  or  $-CR^A R^B-CH_2-CR^A R^B-$ ),  $CR^A R^B C(O)$  and  $CR^A R^B C(O)CR^A R^B$   
10 (preferably  $CH_2C(O)CH_2$ ); alternatively Y is selected from the group consisting of O and S and X is selected from the group consisting of  $CR^A R^B$  and  $C(O)$ ;

provided that when X is S, then Y is selected from the group consisting of  $CR^A R^B$ ,  $CR^A R^B(CR^A R^B)_{1-2}$  and  $CH_2C(O)CH_2$ ; provided further that when Y is S, then X is selected from the group consisting of  $CR^A R^B$ ;

15 wherein each  $R^A$  and  $R^B$  is independently selected from hydrogen, hydroxy, alkyl or alkoxy; provided that  $R^A$  and  $R^B$  are not each hydroxy;

Z is selected from the group consisting of O and S;

$R^1$  and  $R^2$  are taken together with the carbon atom to which they are bound to form  $C(O)$ ;

20 provided that when X is selected from the group consisting of O and S, then Y is selected from the group consisting of  $CR^A R^B$ ,  $CR^A R^B(CR^A R^B)_{1-2}$ ,  $CR^A R^B C(O)$  and  $CH_2C(O)CH_2$ ;

provided further that when Y is selected from the group consisting of O and S, then X is selected from the group consisting of  $CR^A R^B$ ;

25 n is an integer selected from 0 to 4;

each  $R^3$  is independently selected from the group consisting of halogen, hydroxy,  $R^C$ , amino, alkylamino, dialkylamino, nitro, cyano,  $-C(O)R^G$ ,  $-C(O)OR^G$ ,  $-OC(O)R^G$ ,  $-OC(O)OR^G$ ,  $-OC(O)N(R^G)_2$ ,  $-N(R^G)C(O)R^G$ ,  $-OSi(R^G)_3$ ,  $-OR^G$ ,  $-SO_2N(R^G)_2$ ,  $-O-(alkyl)_{1-4}-C(O)R^G$  and  $-O-(alkyl)_{1-4}-C(O)OR^G$ ;

30 wherein  $R^C$  is selected from the group consisting of alkyl, cycloalkyl, cycloalkyl-alkyl, aryl, aralkyl, heteroaryl, heteroaryl-alkyl, heterocycloalkyl and heterocycloalkyl-alkyl; wherein the cycloalkyl, cycloalkyl-alkyl, aryl, aralkyl,



heteroaryl, heteroaryl-alkyl, heterocycloalkyl or heterocycloalkyl-alkyl group is optionally substituted with one or more substituents independently selected from halogen, hydroxy, alkyl, alkoxy, -SH, -S(alkyl), SO<sub>2</sub>, NO<sub>2</sub>, CN, CO<sub>2</sub>H, R<sup>C</sup>, -SO<sub>2</sub>-NR<sup>D</sup>R<sup>E</sup>, NR<sup>D</sup>R<sup>E</sup>, NR<sup>D</sup>-SO<sub>2</sub>-R<sup>F</sup>, -(alkyl)<sub>0-4</sub>-C(O)-NR<sup>D</sup>R<sup>E</sup>, -(alkyl)<sub>0-4</sub>-NR<sup>D</sup>-C(O)-R<sup>F</sup>, -(alkyl)<sub>0-4</sub>-(Q)<sub>0-1</sub>-(alkyl)<sub>0-4</sub>-NR<sup>D</sup>R<sup>E</sup>, -(alkyl)<sub>0-4</sub>-(Q)<sub>0-1</sub>-(alkyl)<sub>0-4</sub>-C(O)-OR<sup>F</sup>, -(alkyl)<sub>0-4</sub>-(Q)<sub>0-1</sub>-(alkyl)<sub>0-4</sub>-C(O)-NR<sup>D</sup>R<sup>E</sup> or -(alkyl)<sub>0-4</sub>-C(O)-(alkyl)<sub>0-4</sub>-C(O)-OR<sup>F</sup>; wherein Q is selected from the group consisting of O, S, NH, N(alkyl) and -CH=CH-;

wherein each R<sup>D</sup> and R<sup>E</sup> is independently selected from the group consisting of hydrogen and alkyl; alternatively R<sup>D</sup> and R<sup>E</sup> are taken together with the nitrogen atom to which they are bound to form a 3 to 10 membered, preferably 4 to 8 membered, ring selected from the group consisting of heteroaryl or heterocycloalkyl; wherein the heteroaryl or heterocycloalkyl group is optionally substituted with one or more substituents independently selected from halogen, hydroxy, oxo, alkyl, alkoxy, carboxy, amino, alkylamino, dialkylamino, nitro or cyano;

wherein R<sup>F</sup> is selected from the group consisting of hydrogen, alkyl, cycloalkyl, cycloalkyl-alkyl, aryl, aralkyl, heteroaryl, heteroaryl-alkyl, heterocycloalkyl and heterocycloalkyl-alkyl; wherein the cycloalkyl, aryl, heteroaryl, heteroaryl-alkyl, heterocycloalkyl or heterocycloalkyl-alkyl group is optionally substituted with one or more substituents independently selected from halogen, hydroxy, alkyl, alkoxy, carboxy, amino, alkylamino, dialkylamino, nitro or cyano;

wherein each R<sup>G</sup> is independently selected from hydrogen, alkyl, aryl, aralkyl and 1,7,7-trimethyl-2-oxabicyclo[2.2.1]heptan-3-one; wherein the alkyl, aryl or aralkyl group is optionally substituted with one or more substituents independently selected from alkyl, halogenated alkyl, alkoxy, halogen, hydroxy, nitro, cyano, -OC(O)-alkyl or -C(O)O-alkyl;

alternatively two R<sup>G</sup> groups are taken together with the nitrogen atom to which they are bound to form a heterocycloalkyl group; wherein the heterocycloalkyl group is optionally substituted with one or more substituents

independently selected from halogen, hydroxy, alkyl, alkoxy, carboxy, amino, alkylamino, dialkylamino, nitro or cyano;

m is an integer selected from 0 to 4;

each  $R^4$  is independently selected from the group consisting of halogen, hydroxy,  $R^C$ , amino, alkylamino, dialkylamino, nitro, cyano,  $-C(O)R^G$ ,  $-C(O)OR^G$ ,  $-OC(O)R^G$ ,  $-OC(O)OR^G$ ,  $-OC(O)N(R^G)_2$ ,  $-N(R^G)C(O)R^G$ ,  $-OSi(R^G)_3$ ,  $-OR^G$ ,  $-SO_2N(alkyl)_2$ ,  $-O-(alkyl)_{1-4}-C(O)R^G$  and  $-O-(alkyl)_{1-4}-C(O)OR^G$ ;

provided that when  $====$  is a double bond, X is  $CH_2$ , Y is O, Z is O and  $R^1$  and  $R^2$  are taken together with the carbon atom to which they are bound to form  $C(O)$ , then at least one of n or m is an integer selected from 1 to 4; preferably, n is an integer from 1 to 4 and m is an integer from 1 to 4;

provided further that when  $====$  is a double bond, X is O, Y is  $CH_2$ , Z is O,  $R^1$  and  $R^2$  are taken together with the carbon atom to which they are bound to form  $C(O)$ , n is 0 and m is 2, then each  $R^4$  is not hydroxy or alkoxy.

or a pharmaceutically acceptable salt thereof.

In an embodiment of the present invention are compounds of formula (D) wherein  $====$  represents a single or double bond,

A is selected from the group consisting of O and S;

D is selected from the group consisting of hydrogen, methyl, acetyl, benzoyl, SEM, MOM, BOM, TBS, pivaloyl and  $-C(O)R$ ; wherein R is selected from alkyl, aryl, and substituted aryl; wherein the substituents on the aryl group are one or more independently selected from halogen, hydroxy, alkyl, alkoxy, amino, alkylamino, di(alkyl)amino, nitro or cyano;

each  $R^{10}$  and  $R^{11}$  is independently selected from hydrogen, halogen, hydroxy, alkyl, hydroxy substituted alkyl, alkoxy,  $-CH(OH)-aryl$ ,  $-CHO$ ,  $-C(O)-aryl$ ,  $-C(O)O-alkyl$ ,  $-C(O)O-aryl$  and pivaloyl; provided that  $R^{10}$  and  $R^{11}$  are not each hydroxy;

Z is selected from the group consisting of O and S;

n is an integer selected from 0 to 4;

each R<sup>12</sup> is independently selected from the group consisting of hydroxy, alkoxy, trialkylsilyl, acyloxy, benzoyloxy, aryloxy, aralkyloxy, SEMoxy, MOMoxy and pivaloyloxy;

m is an integer selected from 0 to 4;

5 each R<sup>13</sup> is independently selected from the group consisting of hydroxy, alkoxy, trialkylsilyl, acyloxy, benzoyloxy, aryloxy, aralkyloxy, SEMoxy, MOMoxy and pivaloyloxy;

10 In an embodiment of the present invention are compounds of formula (D) wherein A is O and Z is O.

In an embodiment of the present invention R<sup>10</sup> and R<sup>11</sup> are each independently selected from the group consisting of hydrogen, halogen, hydroxy substituted alkyl, halogen substituted alkyl, -CHO, -CH(OH)-phenyl, 15 aryl (wherein the aryl group is optionally substituted with a hydroxy, alkoxy or alkoxycarbonyl), -C(O)-alkyl, -C(O)-(halogen substituted alkyl), -C(O)-phenyl, -C(O)O-alkyl, -C(O)-(alkyl)-O-(alkyl), -C(O)O-phenyl, -(alkyl)-O-(alkyl) and -(alkyl)-O-(alkyl)-Si(alkyl)<sub>3</sub>. In a preferred embodiment of the present invention R<sup>10</sup> is selected from the group consisting of hydrogen and bromo, preferably 20 hydrogen; and R<sup>11</sup> is selected from the group consisting of hydrogen, bromo, iodo-methyl, chloromethyl, -CHO, -CH<sub>2</sub>OH, CH(OH)CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>, -CH(OH)-phenyl, 4-hydroxy-phenyl, 4-methoxy-phenyl, 4-(methoxy-carbonyl)-phenyl, -C(O)-CH<sub>2</sub>-Cl, -C(O)OCH<sub>3</sub>, -C(O)-CH<sub>2</sub>-O-CH<sub>3</sub>, -C(O)O-phenyl, -CH<sub>2</sub>-O-CH<sub>3</sub> and -CH<sub>2</sub>-O-CH<sub>2</sub>CH<sub>2</sub>-Si(CH<sub>3</sub>)<sub>3</sub>.

25 In another embodiment of the present invention R<sup>10</sup> and R<sup>11</sup> are each independently selected from the group consisting of hydrogen, halogen, hydroxy substituted alkyl, -CHO, -CH(OH)-phenyl, -C(O)-phenyl, -C(O)O-alkyl and -C(O)O-phenyl. In a preferred embodiment of the present invention R<sup>10</sup> is hydrogen and R<sup>11</sup> is selected from the group consisting of hydrogen, bromine, - 30 CHO, -CH<sub>2</sub>OH, CH(OH)CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>, -CH(OH)-phenyl, -C(O)OCH<sub>3</sub> and -C(O)O-phenyl.

In an embodiment of the present invention  $R^{12}$  and  $R^{13}$  are each independently selected from the group consisting of halogen, hydroxy, lower alkyl, lower alkoxy, aralkyloxy, SEMoxy MOMoxy, pivaloyloxy and  $-\text{OSi}(\text{lower alkyl})_3$ . In another embodiment of the present invention  $R^{12}$  and  $R^{13}$  are each independently selected from the group consisting of halogen, hydroxy, methyl, methoxy, ethoxy, isopropoxy, benzoyloxy, SEMoxy MOMoxy, pivaloyloxy and t-butyl-dimethyl-silyloxy. In yet another embodiment of the present invention  $R^{12}$  and  $R^{13}$  are each independently selected from the group consisting of hydroxy, methoxy, ethoxy, isopropoxy, benzoyloxy, SEMoxy MOMoxy and pivaloyloxy. In yet another embodiment  $R^{12}$  and  $R^{13}$  are each independently selected from the group consisting of hydroxy, methoxy, benzyloxy, benzoyloxy, MOMoxy, SEMoxy and pivaloyloxy.

In an embodiment of the present invention D is selected from the group consisting of hydrogen, methyl, methyl-carbonyl, benzoyl, SEM, MOM and pivaloyl. In another embodiment of the present invention D is selected from the group consisting of hydrogen, methyl, benzoyl, SEM, MOM and pivaloyl.

In an embodiment of the present invention are compounds of formula (DI) wherein Y is selected from the group consisting of  $-\text{CH}_2-$  and  $-\text{CH}_2\text{CH}_2-$ .

In another embodiment of the present invention are compounds of formula (DI) wherein T is selected from the group consisting of  $-(\text{aryl})-\text{O}-(\text{alkyl})-\text{NR}^{\text{D}}\text{R}^{\text{E}}$  and  $-(\text{aryl})-\text{O}-(\text{alkyl})-\text{OH}$ . Preferably, T is selected from the group consisting of 4-(piperidinyl-ethoxy)-phenyl and 4-(3-hydroxy-prop-1-yl-oxy)-phenyl. In yet another embodiment of the present invention, T is selected from the group consisting of  $-(\text{phenyl})-\text{O}-(\text{lower alkyl})-\text{NR}^{\text{D}}\text{R}^{\text{E}}$ .

In an embodiment of the present invention is a process for the preparation of a compound of formula (DX), as described in more detail in Scheme 16, which follows herein.

In another embodiment of the present invention is a process for the preparation of a compound of formula (DXI), as described in more detail in Scheme 17, which follows herein.

5 In another embodiment of the present invention is a process for the preparation of a compound of formula (C), as described in more detail in Schemes 16 and 17, which follow herein.

10 In yet another embodiment of the present invention, is a process for the preparation of a compound of formula (I) comprising reacting a compound of formula (DX) or a compound of formula (DXI) according to the process outlined in Scheme 3, Scheme 10, Scheme 12 or Scheme 15, which follow herein.

15 In an embodiment of the present invention, is a compound prepared according to any of the processes described herein.

For use in medicine, the salts of the compounds of this invention refer to non-toxic "pharmaceutically acceptable salts." Other salts may, however, be useful in the preparation of compounds according to this invention or of their pharmaceutically acceptable salts. Suitable pharmaceutically acceptable salts of the compounds include acid addition salts which may, for example, be formed by mixing a solution of the compound with a solution of a pharmaceutically acceptable acid such as hydrochloric acid, sulfuric acid, fumaric acid, maleic acid, succinic acid, acetic acid, benzoic acid, citric acid, tartaric acid, carbonic acid or phosphoric acid. Furthermore, where the compounds of the invention carry an acidic moiety, suitable pharmaceutically acceptable salts thereof may include alkali metal salts, e.g., sodium or potassium salts; alkaline earth metal salts, e.g., calcium or magnesium salts; and salts formed with suitable organic ligands, e.g., quaternary ammonium salts. Thus, representative pharmaceutically acceptable salts include the following:

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acetate, benzenesulfonate, benzoate, bicarbonate, bisulfate, bitartrate, borate, bromide, calcium edetate, camsylate, carbonate, chloride, clavulanate,

citrate, dihydrochloride, edetate, edisylate, estolate, esylate, fumarate, gluceptate, gluconate, glutamate, glycolylarsanilate, hexylresorcinate, hydrabamine, hydrobromide, hydrochloride, hydroxynaphthoate, iodide, isothionate, lactate, lactobionate, laurate, malate, maleate, mandelate, mesylate, methylbromide, methylnitrate, methylsulfate, mucate, napsylate, nitrate, N-methylglucamine ammonium salt, oleate, pamoate (embonate), palmitate, pantothenate, phosphate/diphosphate, polygalacturonate, salicylate, stearate, sulfate, subacetate, succinate, tannate, tartrate, teoclate, tosylate, triethiodide and valerate.

10

The present invention includes within its scope prodrugs of the compounds of this invention. In general, such prodrugs will be functional derivatives of the compounds which are readily convertible *in vivo* into the required compound. Thus, in the methods of treatment of the present invention, the term "administering" shall encompass the treatment of the various disorders described with the compound specifically disclosed or with a compound which may not be specifically disclosed, but which converts to the specified compound *in vivo* after administration to the patient. Conventional procedures for the selection and preparation of suitable prodrug derivatives are described, for example, in "Design of Prodrugs", ed. H. Bundgaard, Elsevier, 1985.

Where the compounds according to this invention have at least one chiral center, they may accordingly exist as enantiomers. Where the compounds possess two or more chiral centers, they may additionally exist as diastereomers. It is to be understood that all such isomers and mixtures thereof are encompassed within the scope of the present invention. Furthermore, some of the crystalline forms for the compounds may exist as polymorphs and as such are intended to be included in the present invention. In addition, some of the compounds may form solvates with water (i.e., hydrates) or common organic solvents, and such solvates are also intended to be encompassed within the scope of this invention.

As used herein, the term "degenerative brain disease" shall include cognitive disorder, dementia, regardless of underlying cause and Alzheimer's disease.

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As used herein, the term "cardiovascular disease" shall include elevated blood lipid levels, coronary atherosclerosis and coronary heart disease.

10 As used herein, the term "cerebrovascular disease" shall include abnormal regional cerebral blood flow and ischemic brain damage.

As used herein, the term "progestogen antagonist" shall include mifepristone (RU-486), J-867 (Jenapharm / TAP Pharmaceuticals), J-956 (Jenapharm / TAP Pharmaceuticals), ORG-31710 (Organon), ORG-32638 (Organon), ORG-31806 (Organon), onapristone (ZK98299) and PRA248 (Wyeth).

As used herein, unless otherwise noted, "halogen" shall mean chlorine, bromine, fluorine and iodine.

20 As used herein, unless otherwise noted, the term "alkyl" whether used alone or as part of a substituent group, include straight and branched chain compositions of one to eight carbon atoms. For example, alkyl radicals include methyl, ethyl, propyl, isopropyl, butyl, isobutyl, sec-butyl, t-butyl, pentyl and the like. Unless otherwise noted, "lower" when used with alkyl means a carbon  
25 chain composition of 1-4 carbon atoms. Similarly, the group "-(alkyl)<sub>0-4</sub>", whether alone or as part of a large substituent group, shall mean the absence of an alkyl group or the presence of an alkyl group comprising one to four carbon atoms. Suitable examples include, but are not limited to -CH<sub>2</sub>-, -CH<sub>2</sub>CH<sub>2</sub>-, CH<sub>2</sub>-CH(CH<sub>3</sub>)-, CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>-, -CH<sub>2</sub>CH(CH<sub>3</sub>)CH<sub>2</sub>-, CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>-, and the like.

30

As used herein, unless otherwise noted, the term "alkenyl" shall mean a carbon chain comprising one to eight carbon atom and containing at least one

double bond. Suitable examples include but are not limited to, allyl, crotyl, 2-butenyl, 2-pentenyl, and the like. Unless otherwise noted, "lower" when used with alkenyl shall mean an alkenyl carbon chain comprising one to four carbon atoms, such as allyl, and the like.

5

As used herein, unless otherwise noted, "alkoxy" shall denote an oxygen ether radical of the above described straight or branched chain alkyl groups. For example, methoxy, ethoxy, n-propoxy, sec-butoxy, t-butoxy, n-hexyloxy and the like. Unless otherwise noted, "lower" when used with alkoxy means an alkoxy group (an oxygen ether radical as described above) comprising one to four carbon atoms. Suitable examples include, but are not limited to methoxy, ethoxy, isopropoxy, n-propoxy, and the like.

10

As used herein, unless otherwise noted, "aryl" shall refer to unsubstituted carbocyclic aromatic groups such as phenyl, naphthyl, and the like.

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As used herein, unless otherwise noted, "aralkyl" shall mean any lower alkyl group substituted with an aryl group such as phenyl, naphthyl and the like. Suitable examples include benzyl, phenylethyl, phenylpropyl, naphthylmethyl, and the like.

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As used herein, unless otherwise noted, the term "cycloalkyl" shall mean any stable 3-8 membered monocyclic, saturated ring system, for example cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl and cyclooctyl.

25

As used herein, unless otherwise noted, the term "cycloalkyl-alkyl" shall mean any lower alkyl group substituted with a cycloalkyl group. Suitable examples include, but are not limited to cyclohexyl-methyl, cyclopentyl-methyl, cyclohexyl-ethyl, and the like.

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As used herein, unless otherwise noted, the terms "acyloxy" shall mean a radical group of the formula  $-O-C(O)-R$  where R is alkyl, aryl or aralkyl, wherein



the alkyl, aryl or aralkyl is optionally substituted. As used herein, the term "carboxylate" shall mean a radical group of the formula  $-C(O)O-R$  where R is alkyl, aryl or aralkyl, wherein the alkyl, aryl or aralkyl is optionally substituted.

5 As used herein, unless otherwise noted, "heteroaryl" shall denote any three to ten membered monocyclic or bicyclic aromatic ring structure containing at least one heteroatom selected from the group consisting of O, N and S, optionally containing one to four additional heteroatoms independently selected from the group consisting of O, N and S. Preferably, the heteroaryl group is a five or six  
10 membered monocyclic aromatic ring structure containing at least one heteroatom selected from the group consisting of O, N and S, optionally containing one to three additional heteroatoms independently selected from the group consisting of O, N and S; or a nine or ten membered bicyclic aromatic ring structure containing at least one heteroatom selected from the group consisting of O, N and S,  
15 optionally containing one to four additional heteroatoms independently selected from the group consisting of O, N and S. The heteroaryl group may be attached at any heteroatom or carbon atom of the ring such that the result is a stable structure.

Examples of suitable heteroaryl groups include, but are not limited to,  
20 pyrrolyl, furyl, thienyl, oxazolyl, imidazolyl, purazolyl, isoxazolyl, isothiazolyl, triazolyl, thiadiazolyl, pyridyl, pyridazinyl, pyrimidinyl, pyrazinyl, pyranlyl, furazanyl, indolizinyll, indolyl, isoindolinyll, indazolyl, benzofuryl, benzothienyl, benzimidazolyl, benzthiazolyl, purinyl, quinolizinyll, quinolinyll, isoquinolinyll, isothiazolyl, cinnolinyll, phthalazinyl, quinazolinyll, quinoxalinyll, naphthyridinyll,  
25 pteridinyll, and the like.

As used herein, unless otherwise noted, the term "heteroaryl-alkyl" shall mean any lower alkyl group substituted with a heteroaryl group. Suitable examples include, but are not limited to pyridyl-methyl, isoquinolinyll-methyl,  
30 thiazolyl-ethyl, furyl-ethyl, and the like.

As used herein, the term "heterocycloalkyl" shall denote any three to ten membered monocyclic or bicyclic, saturated, partially unsaturated or partially aromatic ring structure containing at least one heteroatom selected from the group consisting of O, N and S, optionally containing one to four additional  
5 heteroatoms independently selected from the group consisting of O, N and S. Preferably, the heterocycloalkyl is a five to seven membered monocyclic, saturated or partially unsaturated ring structure containing at least one heteroatom selected from the group consisting of O, N and S, optionally containing one to three additional heteroatoms independently selected from the  
10 group consisting of O, N and S; or a nine to ten membered saturated, partially unsaturated or partially aromatic bicyclic ring system containing at least one heteroatom selected from the group consisting of O, N and S, optionally containing one to four additional heteroatoms independently selected from the group consisting of O, N and S. The heterocycloalkyl group may be attached at  
15 any heteroatom or carbon atom of the ring such that the result is a stable structure.

Examples of suitable heteroaryl groups include, but are not limited to, pyrrolinyl, pyrrolidinyl, dioxalanyl, imidazolanyl, imidazolidinyl, pyrazolanyl, pyrazolidinyl, piperidinyl, dioxanyl, morpholinyl, dithianyl, thiomorpholinyl,  
20 piperazinyl, trithianyl, indolinyl, chromenyl, 3,4-methylenedioxyphenyl, 2,3-dihydrobenzofuryl, and the like.

Preferred heterocycloalkyl groups include morpholinyl, piperidinyl, piperazinyl, pyrrolidinyl, azepanyl and 2-oxabicyclo[2.2.1]heptane.

25 As used herein, unless otherwise noted, the term "heterocycloalkyl-alkyl" shall mean any lower alkyl group substituted with a heterocycloalkyl group. Suitable examples include, but are not limited to piperidinyl-methyl, piperazinyl-methyl, piperazinyl-ethyl, morpholinyl-methyl, and the like.

30 As used herein the term "N containing heterocycloalkyl (wherein said N containing heterocycloalkyl is bound through the N atom)" shall mean any heterocycloalkyl as described above which contains at least one N atom and

which is bound through said N atom. Suitable examples include, but are not limited to 1-piperidinyl, 4-piperazinyl, 1-pyrrolidinyl, 4-morpholinyl, 1-azepanyl, and the like.

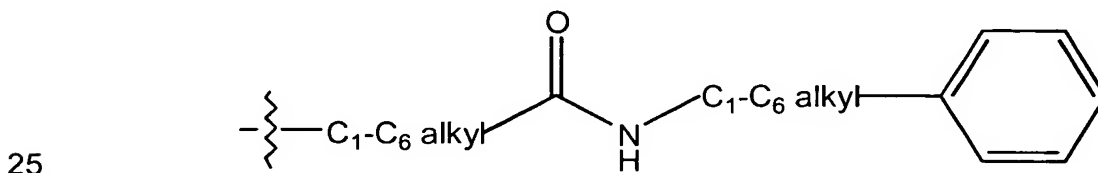
- 5 As used herein, the notation "\*" shall denote the presence of a stereogenic center.

When a particular group is "substituted" (e.g., cycloalkyl, aryl, heteroaryl, heterocycloalkyl), that group may have one or more substituents, preferably  
 10 from one to five substituents, more preferably from one to three substituents, most preferably from one to two substituents, independently selected from the list of substituents. Additionally when aralkyl, heteroaryl-alkyl, heterocycloalkyl-alkyl or cycloalkyl-alkyl group is substituted, the substituent(s) may be on any portion of the group (i.e. the substituent(s) may be on the aryl, heteroaryl,  
 15 heterocycloalkyl, cycloalkyl or the alkyl portion of the group.)

With reference to substituents, the term "independently" means that when more than one of such substituents is possible, such substituents may be the same or different from each other.

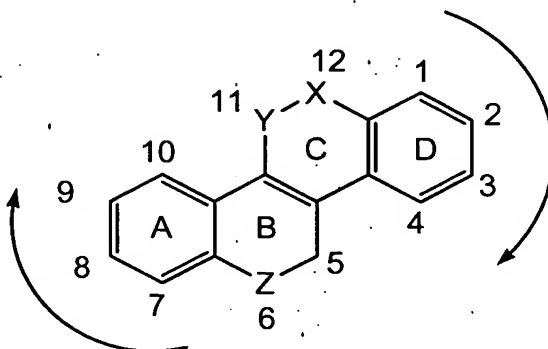
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Under standard nomenclature used throughout this disclosure, the terminal portion of the designated side chain is described first, followed by the adjacent functionality toward the point of attachment. Thus, for example, a "phenylC<sub>1</sub>-C<sub>6</sub>alkylaminocarbonylC<sub>1</sub>-C<sub>6</sub>alkyl" substituent refers to a group of the formula



Unless otherwise noted, when naming substituents such as R<sup>3</sup> and R<sup>4</sup> groups, the following numbering of the core structure will be applied. The

capital letters A, B, C and D will be used to designate specific rings of the tetracyclic core structure.



5 As used herein, the term "leaving group" shall mean any group which leaves a substrate during a reaction in which the substrate is cleaved. Suitable examples include, but are not limited to, Cl, Br, I, tosylate, mesylate, triflate, hydroxy, and the like.

10 As used herein, the term "electrophile" shall mean an atom or molecule which takes a pair of electron. Suitable example include, but are not limited to, Br, Cl, I, CH<sub>3</sub>, SEM, MOM, BOM, -C(O)CH<sub>2</sub>-OCH<sub>3</sub>, -C(O)-CH<sub>2</sub>-Cl, -C(O)-CH<sub>2</sub>-Br, -C(O)-CH<sub>2</sub>-(lower alkyl), -C(O)-CH<sub>2</sub>-(benzyl), -C(O)-CH<sub>2</sub>-(aryl), -CH<sub>2</sub>-C(O)O-(lower alkyl), and the like.

15

Abbreviations used in the specification, particularly the Schemes and Examples, are as follows

Ac	=	Acetyl group (-C(O)-CH <sub>3</sub> )
AD	=	Alzheimer's disease
AIBN	=	2,2'-Azobisisobutyronitrile
BF <sub>3</sub> •Et <sub>2</sub> O	=	Boron trifluoride etherate
BOM	=	Benzyloxy methyl
BOMCl	=	Benzyloxy methyl chloride
BOMoxy	=	Benzyloxy methyl-oxy
Bz	=	Benzoyl
CSA	=	Camphor sulfonic acid

DCC	=	1,3-Dicyclohexylcarbodiimide
DCE	=	1,1-Dichloroethane
DCM	=	Dichloromethane
DEAD	=	Diethylazodicarboxylate
DIAD	=	Diisopropylazodicarboxylate
Dibal-H or DIBAL	=	Diisobutyl aluminum hydride
DIC	=	Diisopropylcarbodiimide
DIPEA or DIEA	=	Diisopropylethylamine
DMAP	=	N,N-Dimethylaminopyridine
DMF	=	Dimethyl formamide
DTT	=	Dithiothreitol
ERT	=	Estrogen replacement therapy
Et	=	ethyl (i.e. $-\text{CH}_2\text{CH}_3$ )
EtOAc	=	Ethyl acetate
EtOH	=	Ethanol
FBS	=	Fetal bovine serum
HEPES	=	4-(2-Hydroxyethyl)-1-piperazine ethane sulfonic acid
HPLC	=	High pressure liquid chromatography
HRT	=	Hormone replacement therapy
IPA or iPrOH	=	Isopropyl alcohol
iPr <sub>2</sub> NH	=	Diisopropylamine
LAH	=	Lithium aluminum hydride
LDA	=	Lithium Diisopropylamide
LHMDS or LiHMDS or (TMS) <sub>2</sub> NLi or LiN(TMS) <sub>2</sub>	=	Lithium Hexamethyldisilazinamide
KHMDS	=	Potassium Hexamethyldisilazinamide
Me	=	methyl ( $-\text{CH}_3$ )
MeOH	=	Methanol
MOM	=	Methoxy methyl
MOMCl	=	Methoxy methyl chloride
MOMoxy	=	Methoxy methyl-oxy

NaHMDS	=	Sodium Hexamethyldisilazinamide
NBS	=	N-Bromosuccinimide
n-BuLi	=	n-butyl lithium
nBu <sub>3</sub> SnH	=	n-Tributyltin hydride
NCS	=	N-chlorosuccinimide
OAc	=	Acetoxy
OTBS	=	t-Butyl-dimethyl-silyloxy
PBS	=	Phosphate buffered solution
PCC	=	Pyridinium chlorochromate
PDC	=	Pyridinium dichromate
Ph	=	Phenyl
PIV or Piv	=	Pivaloyl
PMB	=	Para-methoxy-benzyl
P(Ph) <sub>3</sub>	=	Triphenylphosphine
PPTS	=	Pyridinium p-toluenesulfonate
Rochelle Solution	=	Aqueous solution of potassium sodium tartrate tetrahydrate
SEM	=	2-(Trimethylsilyl)ethoxy methyl
SEMCI	=	2-(Trimethylsilyl)ethoxy methyl chloride
SEMoxy	=	2-(Trimethylsilyl)ethoxy methyl-oxy
SERM	=	Selective estrogen receptor modulator
TBAF	=	Tetra( <i>n</i> -butyl)ammonium fluoride
TBDMS	=	<i>Tert</i> -butyldimethylsilane
TBS	=	<i>Tert</i> -butyl-dimethyl-silyl
TBSCI	=	<i>Tert</i> -butyl-dimethyl-silyl <i>chloride</i>
TEA or Et <sub>3</sub> N	=	Triethylamine
TFA	=	Trifluoroacetic acid
THF	=	Tetrahydrofuran
TIPSCI	=	Triisopropylsilyl chloride
TIPSOTf	=	Triisopropylsilyl trifluoromethane sulfonate
TMS	=	Trimethylsilyl
TMSCHN <sub>2</sub>	=	Trimethylsilyl diazomethane

TPAP = Tetra-n-propylammonium perruthenate  
TsOH = Tosic acid

The term "subject" as used herein, refers to an animal, preferably a mammal, most preferably a human, who has been the object of treatment, observation or experiment.

5

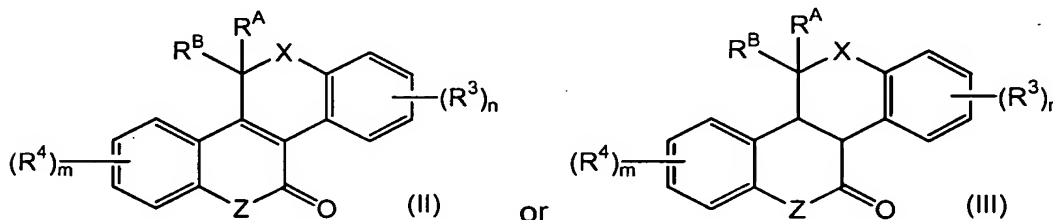
The term "therapeutically effective amount" as used herein, means that amount of active compound or pharmaceutical agent that elicits the biological or medicinal response in a tissue system, animal or human that is being sought by a researcher, veterinarian, medical doctor or other clinician, which includes  
10 alleviation of the symptoms of the disease or disorder being treated. Wherein the present invention directed to co-therapy comprising administration of one or more compound(s) of formula I and a progestogen or progestogen antagonist, "therapeutically effective amount" shall mean that amount of the combination of agents taken together so that the combined effect elicits the desired biological  
15 or medicinal response. For example, the therapeutically effective amount of co-therapy comprising administration of a compound of formula I and progestogen would be the amount of the compound of formula I and the amount of the progestogen that when taken together or sequentially have a combined effect that is therapeutically effective. Further, it will be recognized  
20 by one skilled in the art that in the case of co-therapy with a therapeutically effective amount, as in the example above, the amount of the compound of formula I and/or the amount of the progestogen or progestogen antagonist individually may or may not be therapeutically effective.

25 As used herein, the term "co-therapy" shall mean treatment of a subject in need thereof by administering one or more compounds of formula I with a progestogen or progestogen antagonist, wherein the compound(s) of formula I and progestogen or progestogen antagonist are administered by any suitable means, simultaneously, sequentially, separately or in a single pharmaceutical  
30 formulation. Where the compound(s) of formula I and the progestogen or

progestogen antagonist are administered in separate dosage forms, the number of dosages administered per day for each compound may be the same or different. The compound(s) of formula I and the progestogen or progestogen antagonist may be administered via the same or different routes of administration. Examples of suitable methods of administration include, but are not limited to, oral, intravenous (iv), intramuscular (im), subcutaneous (sc), transdermal, and rectal. Compounds may also be administered directly to the nervous system including, but not limited to, intracerebral, intraventricular, intracerebroventricular, intrathecal, intracisternal, intraspinal and / or peri-spinal routes of administration by delivery via intracranial or intravertebral needles and / or catheters with or without pump devices. The compound(s) of formula I and the progestogen or progestogen antagonist may be administered according to simultaneous or alternating regimens, at the same or different times during the course of the therapy, concurrently in divided or single forms.

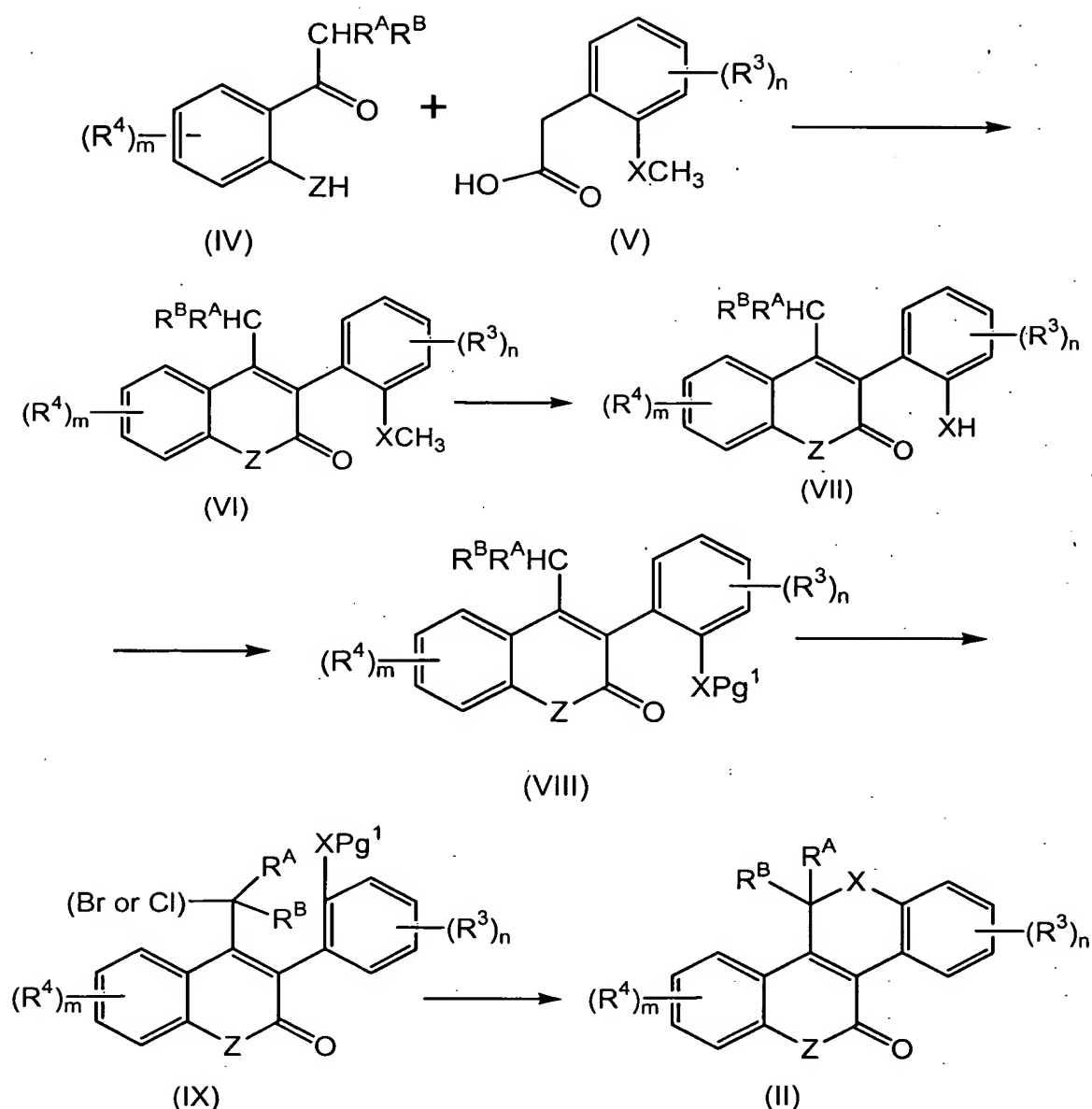
As used herein, the term "composition" is intended to encompass a product comprising the specified ingredients in the specified amounts, as well as any product which results, directly or indirectly, from combinations of the specified ingredients in the specified amounts.

Compounds of formula (I) wherein X is O or S, Y is CH<sub>2</sub> and Z is O or S may be prepared via synthesis through a key intermediate, a compound of formula (II) or (III)



which, in turn, may be prepared according to the processes outlined in Scheme 1 and 2.





5

Scheme 1

More particularly, a suitably substituted compound of formula (IV), where  $Z$  is O or S, a known compound or compound prepared by known methods, is reacted with a suitably substituted compound of formula (V), and where  $X$  is O or S, a known compound or compound prepared by known methods, in the presence of an organic base such as TEA, DIPEA, pyridine, and the like, in an organic solvent such as acetic anhydride, propionic anhydride, butyric anhydride, and the like, at an elevated temperature in the range of about 80°C to about 120°C, to yield the corresponding compound of formula (VI).

The compound of formula (VI) is reacted with a de-methylating reagent such as TMS iodide, BBr<sub>3</sub>, AlCl<sub>3</sub> with ethanethiol, and the like, in a chlorinated solvent such as methylene chloride, chloroform, dichloroethane, and the like, to yield the corresponding compound of formula (VII).

5 Alternatively, the compound of formula (VI) is reacted with a de-methylating reagent such as pyridine hydrochloride, pyridine hydrobromide, pyridine hydroiodide, and the like, optionally in an organic solvent such as xylene, acetic acid, and the like, at an elevated temperature in the range of about 170°C to about 220°C, to yield the corresponding compound of formula  
10 (VII).

The compound of formula (VII) is reacted with a suitably selected protecting reagent such as acetyl chloride, acetic anhydride, benzoyl chloride, BOMCl, MOMCl, SEMCl and the like, in the presence of a base such as pyridine, TEA, DIPEA, K<sub>2</sub>CO<sub>3</sub>, and the like, in an organic solvent such as  
15 methylene chloride, chloroform, acetone, acetonitrile, dichloroethane, and the like, to yield the corresponding compound of formula (VIII), wherein Pg<sup>1</sup> represents a protecting group. For example, wherein the compound of formula (VII) is reacted with acetyl chloride or acetic anhydride, Pg<sup>1</sup> is an acetyl group; wherein the compound of formula (VII) is reacted with benzoyl chloride, Pg<sup>1</sup> is a  
20 benzoyl group; wherein the compound of formula (VII) is reacted with BOMCl, MOMCl or SEMCl, Pg<sup>1</sup> is BOM, MOM or SEM, respectively.

When Pg<sup>1</sup> is acetyl or the like, the compound of formula (VII) is reacted with a radical brominating agent such as NBS, CBrCl<sub>3</sub>, NaBrO<sub>3</sub> in combination with NaHSO<sub>3</sub>, and the like or a radical chlorinating agent, such as NCS;  
25 SO<sub>2</sub>Cl<sub>2</sub>, Cl<sub>2</sub> gas, t-butyl hypochloride, and the like, preferably a radical brominating agent such as NBS, in the presence of a radical initiator such as benzoyl peroxide, AIBN, and the like and/or in the presence of a light source, such as a tungsten lamp, a 120 Watt light bulb, bright sunshine, and the like, optionally at an elevated temperature in the range of about 50°C to about  
30 120°C, to yield the corresponding compound of formula (VIII).

Wherein the compound of formula (VII) is reacted with a radical brominating reagent such as NBS, the reaction is carried out in a halogenated

organic solvent such as carbon tetrachloride, chloroform, dichloromethane, and the like. Wherein the radical brominating reagent is  $\text{NaBrO}_3$ , the reaction is carried out in an organic solvent such as ethyl acetate, cyclohexane, and the like. Wherein the compound of formula (VII) is reacted with a radical  
5 chlorinating reagent, the reaction is carried out in an organic solvent such as ethyl acetate, chloroform, dichloromethane, and the like.

When  $\text{Pg}^1$  is a benzoyl group, pivaloyl, BOM, MOM, SEM, or the like, the compound of formula (VII) is reacted with bromine or a source of bromine or a source of chlorine such as NBS, NCS, and the like, in the presence of a base  
10 such as LHMDs, LDA, KHMDS, NaHMDS, and the like, at a reduced temperature in the range of about  $30^\circ\text{C}$  to about  $-78^\circ\text{C}$ , to yield the corresponding compound of formula (IX).

The compound of formula (IX) is de-protected to yield the corresponding compound of formula (II). When  $\text{Pg}^1$  is acetyl or benzoyl, the compound of  
15 formula (IX) is de-protected with a base such as potassium carbonate, sodium carbonate, cesium carbonate, and the like, in a solvent such as methanol, ethanol, isopropanol, or in a mixture thereof such as methanol:acetone, ethanol:acetone, methanol:acetonitrile, and the like, to yield the corresponding compound of formula (II).

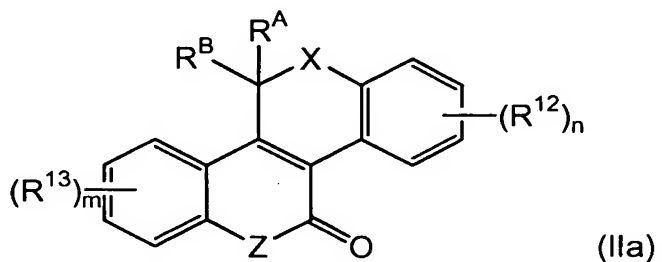
20 When  $\text{Pg}^1$  is methyl, benzyl, BOM, MOM or SEM, the compound of formula (IX) is de-protected with acid such as TFA, HF, HCl,  $\text{H}_2\text{SO}_4$ , and the like, or a Lewis acid such as tin tetrachloride, titanium tetrachloride, boron trichloride, boron tribromide, and the like, or when  $\text{Pg}^1$  is SEM with a de-protecting agent such as  $\text{LiBF}_4$ , TBAF, and the like, in a solvent such as THF,  
25 acetonitrile, methylene chloride, chloroform, isopropanol, methanol, and the like, at a temperature in the range of about  $0^\circ\text{C}$  to about  $50^\circ\text{C}$ , and then treated with a base such as potassium carbonate, sodium carbonate, cesium carbonate, potassium hydroxide, sodium hydroxide, and the like, or an alkali metal alkoxide such as sodium ethoxide, sodium methoxide, sodium t-butoxide,  
30 potassium ethoxide, potassium methoxide, potassium t-butoxide, in a solvent such as methanol, ethanol, isopropanol, THF, or in a mixture thereof such as

methanol:acetone, ethanol:acetone, methanol:acetonitrile, and the like, to yield the corresponding compound of formula (II).

Alternatively, the compound of formula (VI) is reacted with bromine or a source of bromine or chlorine such as NBS, NCS, and the like, in the presence of a base such as LHMDs, LDA, KHMDS, NaHMDS, and the like, at a reduced temperature in the range of about 30°C to about -78°C, to yield the corresponding compound of formula (IX).

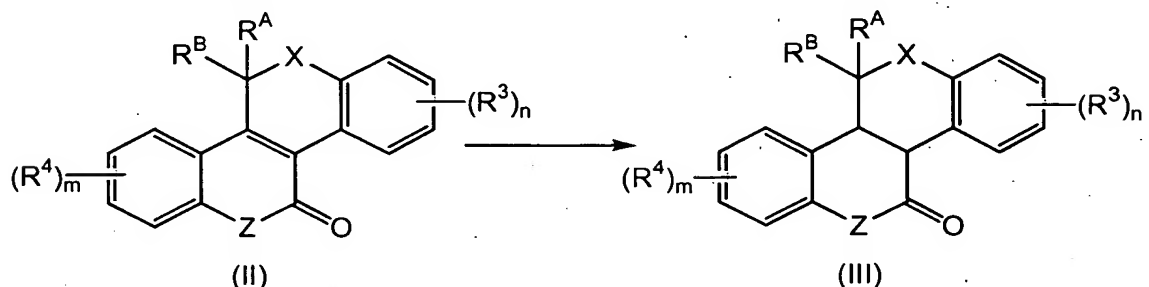
One skilled in the art will recognize that it may be necessary and/or desirable to protect one or more of the  $R^3$  and/or  $R^4$  groups at any of the steps within the process described above. This may be accomplished using known protecting groups and know protection and de-protection reagents and conditions, for example such as those described in Protective Groups in Organic Chemistry, ed. J.F.W. McOmie, Plenum Press, 1973; and T.W. Greene & P.G.M. Wuts, Protective Groups in Organic Synthesis, John Wiley & Sons, 1991.

One skilled in the art will further recognize that the process as described in Scheme 1 above may be applied to compounds of formula (IV) and compounds of formula (V) wherein the  $R^3$  group(s) are substituted with  $R^{12}$  group(s) and the  $R^4$  group(s) are substituted with  $R^{13}$  groups, respectively, wherein  $R^{12}$  and  $R^{13}$  are as herein defined, to yield the corresponding compound of formula (IIa)



The compound of formula (IIa) is then optionally reacted according to known methods (including for example, those disclosed herein) to displace the  $R^{12}$  and  $R^{13}$  group(s) with suitably selected, desired  $R^3$  and  $R^4$  group(s).

The compound of formula (II) may be selectively hydrogenated to yield the corresponding compound of formula (III), as shown in Scheme 2.



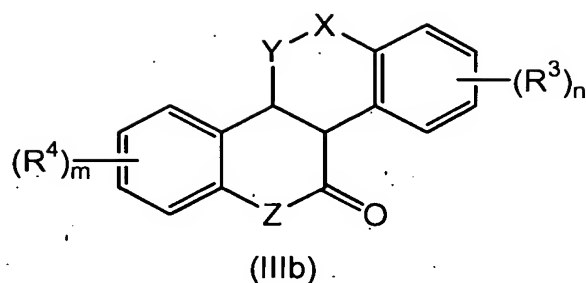
Scheme 2

Accordingly, the compound of formula (II) is reacted with hydrogen gas, at a pressure in the range of about 20 psi to about 100 psi, in the presence of a metal catalyst such as Pd on C, Pt on C, Raney nickel, Pd(OH)<sub>2</sub>, and the like, to yield the corresponding compound of formula (III), as predominately the cis isomer.

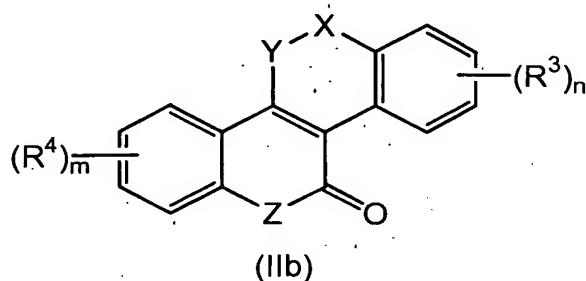
Alternatively, the compound of formula (III) is reacted with a hydride such as LAH, Cu hydride, Sml<sub>2</sub>, Stryker's Reagent ([Ph<sub>3</sub>P]CuH)<sub>6</sub>, and the like, in an solvent such as THF, diethyl ether, and the like, at a temperature in the range of about -20°C to about 60°C, to yield the corresponding compound of formula (III), as predominately the trans isomer.

Alternatively still, the compound of formula (II) is reacted with triethyl silane, in the presence of an acid such as TFA, BF<sub>3</sub> etherate, Tin tertachloride, and the like, in an organic solvent such as methylene chloride, toluene, and the like, to yield the corresponding compound of formula (III), as a mixture of cis and trans isomers.

One skilled in the art will further recognize that the process outlined in Scheme 2 above may be similarly used to prepared compounds of formula (IIIb)

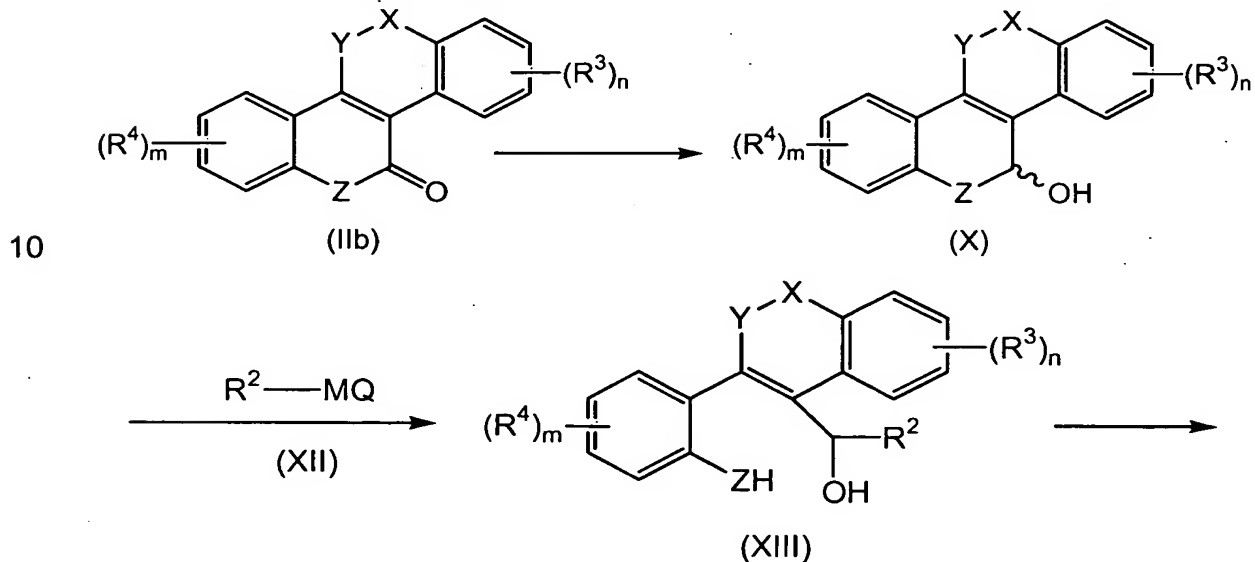


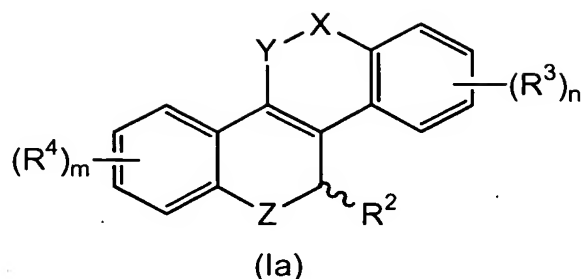
by substituting a suitably substituted compound of formula (IIb)



a known compound or compound prepared by known methods, for the  
5 compound of formula (II).

Compounds of formula (I) wherein X is O or S, Y is  $CR^A R^B$  and Z is O or S may be prepared from the intermediate compound of formula (II) according to the process outlined in Scheme 3.





Scheme 3

Accordingly, the compound of formula (IIb), a known compound or compound prepared by known methods, is reacted with diisobutyl-aluminum hydride, L-selectride, and the like, in an organic solvent such as toluene, benzene, THF, methylene chloride, and the like, at a reduced temperature in the range of about 0°C to about -80°C, to yield the corresponding compound of formula (X).

The compound of formula (X) is reacted with a suitably substituted compound of formula (XII), wherein MQ is lithium or a magnesium halide such as MgCl, MgBr or MgI, prepared from the corresponding known alkyl or aryl halide by known methods, in an organic solvent such as THF, diethyl ether, dioxane, hexane, and the like, to yield the corresponding compound of formula (XIII).

The compound of formula (XIII) is treated with a protic acid such as HCl, H<sub>2</sub>SO<sub>4</sub>, p-toluene sulfonic acid, camphor sulfonic acid (CSA), TFA, and the like or a Lewis acid such as BF<sub>3</sub> etherate, AlCl<sub>3</sub>, SnCl<sub>4</sub>, and the like, in a solvent such as toluene, methylene chloride, acetonitrile and the like, to yield the corresponding compound of formula (Ia).

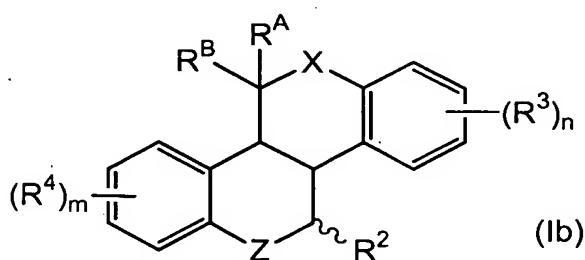
Alternatively, the compound of formula (XIII) is treated with a reagent such as triphenylphosphine, tributylphosphine, and the like, or an azodicarboxamide such as DEAD, DIAD, and the like, in a solvent such as toluene, THF, and the like, to yield the corresponding compound of formula (Ia).

One skilled in the art will recognize that it may be necessary and/or desirable to protect one or more of the R<sup>3</sup> and/or R<sup>4</sup> groups at any of the steps within the process described above. This may be accomplished using known

protecting groups and know protection and de-protection reagents and conditions, for example such as those described in Protective Groups in Organic Chemistry, ed. J.F.W. McOmie, Plenum Press, 1973; and T.W. Greene & P.G.M. Wuts, Protective Groups in Organic Synthesis, John Wiley & Sons, 1991.

One skilled in the art will further recognize that in the process outlined in Scheme 3, when Y is  $-\text{CH}_2\text{C}(\text{O})\text{CH}_2-$  and the compound of formula (IIb) is reacted with a protecting group reagent, to protect any substituent group (for example an  $\text{R}^3$  or  $\text{R}^4$  group), the  $\text{C}(\text{O})$  on the  $-\text{CH}_2\text{C}(\text{O})\text{CH}_2-$  may also react with the protecting group reagent to form  $-\text{CH}=\text{C}(\text{OPg})\text{CH}_2-$  wherein Pg is the protecting group. Upon de-protection, the  $-\text{CH}=\text{C}(\text{OPg})\text{CH}_2-$  is also de-protected to yield  $-\text{CH}_2\text{C}(\text{O})\text{CH}_2-$ .

Alternatively, the compound of formula (III) is substituted for the compound of formula (IIb) in Scheme 3 above, to yield the compound of formula (Ib)

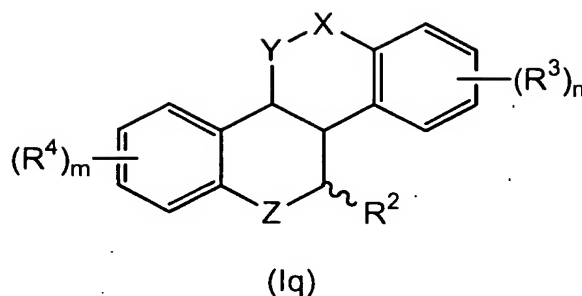


wherein  $\text{R}^2$  as defined above.

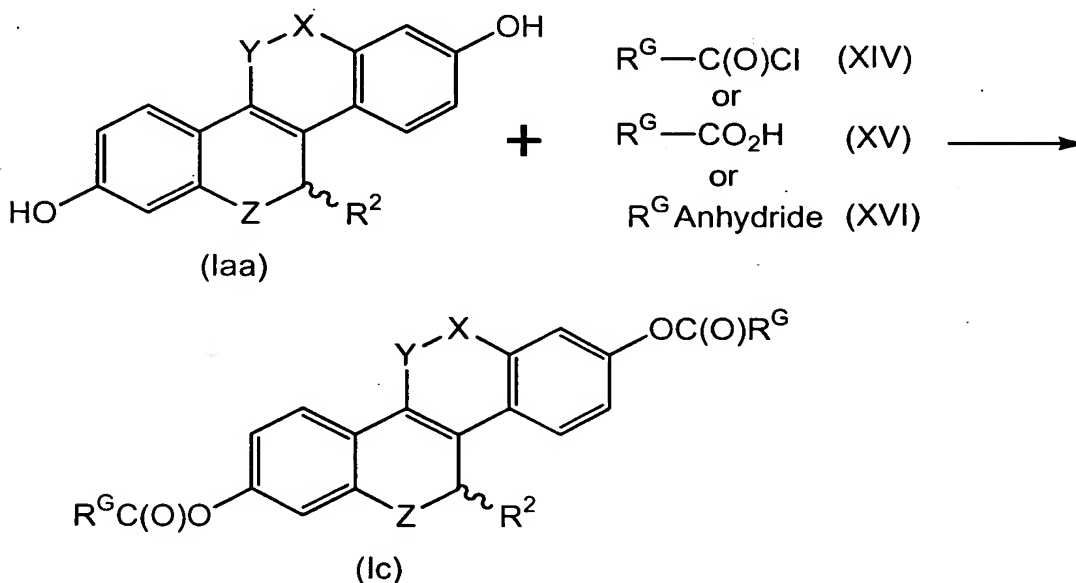
One skilled in the art will recognize that the compound of formula (Ib) may alternatively be prepared by selectively hydrogenating a suitably substituted compound of formula (Ia), wherein Y is  $\text{CR}^{\text{A}}\text{R}^{\text{B}}$ , using reagents and conditions as described in Scheme 2.

One skilled in the art will further recognize that the compound of formula (IIIb) may be similarly substituted for the compound of formula (IIb) in Scheme 3 above, to yield the corresponding compound of formula (Iq)





Compounds of formula (I) wherein one or more  $R^3$  and/or  $R^4$  are acyloxy may be prepared by reacting a suitably substituted compound of formula (I), wherein the  $R^3$  and/or  $R^4$  group(s) are hydroxy with a suitably substituted acid chloride, a suitably substituted carboxylic acid or a suitably substituted anhydride. For example, a compound of formula (I) wherein  $R^3$  and  $R^4$ , at the 2 and 8 positions respectively, are acyloxy may be prepared according to the process outlined in Scheme 4.



Scheme 4

Accordingly, a suitably substituted compound of formula (Iaa) prepared as in Scheme 3 (wherein  $n$  is 1,  $R^3$  is hydroxy,  $m$  is 1 and  $R^4$  is hydroxy), is reacted with a suitably substituted acid chloride, a compound of formula (XIV), or a suitably substituted anhydride, a compound of formula (XVI), wherein  $R^G$  is as defined above, a known compound or compound prepared by known

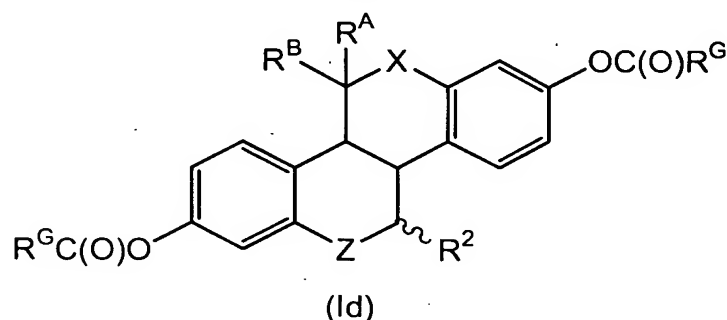
methods, in the presence of an organic amine such as TEA, DIPEA, pyridine, and the like, in a halogenated organic solvent such as DCM, methylene chloride, chloroform, and the like, or in a hydrocarbon solvent such as benzene, toluene, and the like, to yield the corresponding compound of formula (Ic).

5           Alternatively, the compound of formula (Iaa) is reacted with a suitably substituted carboxylic acid, a compound of formula (XV), wherein  $R^G$  is as defined above, a known compound or compound prepared by known methods, in the presence of a coupling reagent such as DCC, DIC, and the like, in an organic solvent such as DMF, THF, methylene chloride, and the like, to yield  
10       the corresponding compound of formula (Ic).

One skilled in the art will recognize that any  $R^3$  and / or  $R^4$  group(s) terminating with a hydroxy group may be similar converted according to the process outlined in Scheme 4 above. One skilled in the art will further  
15       recognize that wherein one or more of the  $R^3$  and/or  $R^4$  groups are hydroxy groups protected with a silyl protecting group such as TBS, the corresponding compound of formula (Ia) is reacted with a tetra-alkyl ammonium fluoride such as TBAF, and the like, and then reacted with a suitably substituted acid chloride of formula (XIV), in an organic solvent such as THF, diethyl ether, and the like,  
20       to yield the corresponding compound of formula (Ic).

One skilled in the art will further recognize that reacting the compound of formula (Iaa) with  $\leq$  about 1 equivalent of a suitably substituted compound of formula (XIV), a suitably substituted compound of formula (XV) or a suitably  
25       substituted compound of formula (XVI), will yield a mixture of compounds wherein only  $R^3$ , only  $R^4$  and both  $R^3$  and  $R^4$  are converted to the group  $-\text{OC}(\text{O})R^G$ . This mixture of compounds is preferably separated by known methods to recover the desired compound. Further, reacting the compound of formula (Iaa) with  $\geq$  about 2 equivalents of a suitably substituted compound of  
30       formula (XIV), a suitably substituted compound of formula (XV) or a suitably substituted compound of formula (XVI), will yield the compound of formula (Ic) wherein both  $R^3$  and  $R^4$  are converted to the group  $-\text{OC}(\text{O})R^G$ .

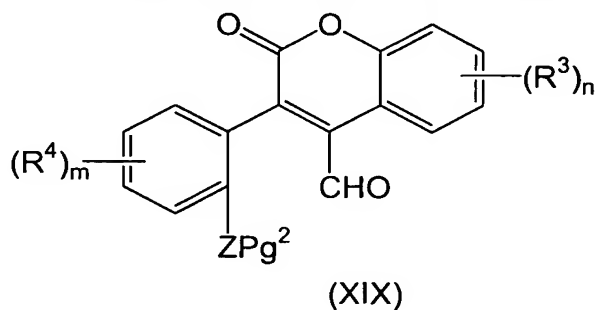
Alternatively, the compound of formula (Iba), a compound of formula (Ib) wherein n is 1, R<sup>3</sup> is hydroxy, m is 1 and R<sup>4</sup> is hydroxy) may substituted for the compound of formula (Iaa) and reacted as described in Scheme 4, to yield the  
 5 corresponding compound of formula (Id)



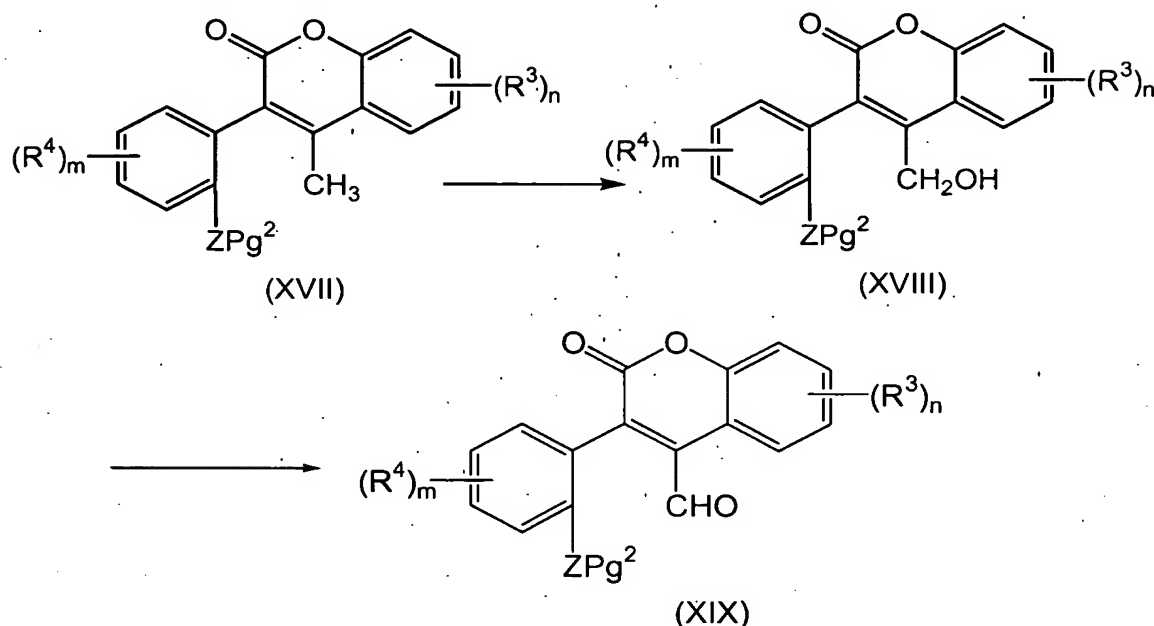
One skilled in the art will further recognize that the above reaction can be tailored to the preparation of compound of formula (I) and (II) wherein the  
 10 position of the R<sup>3</sup> and R<sup>4</sup> group may be varied about the A and D rings respectively, and where the number of R<sup>3</sup> and R<sup>4</sup> groups is varied.

Further, one skilled in the art will recognize that if different acyloxy groups are desired at the R<sup>3</sup> and R<sup>4</sup> positions, the acyloxy groups may be sequentially coupled onto the core structure through conversion of a hydroxy  
 15 group as described in Scheme 4 above, with suitable protection and de-protection of reactive groups as necessary.

Compounds of formula (I) wherein X is O, Y is CH<sub>2</sub> or C(O) and Z is O or S may be from the intermediate compound of formula (XIX).



The compound of formula (XIX) may be prepared according to the process outlined in Scheme 5.



5

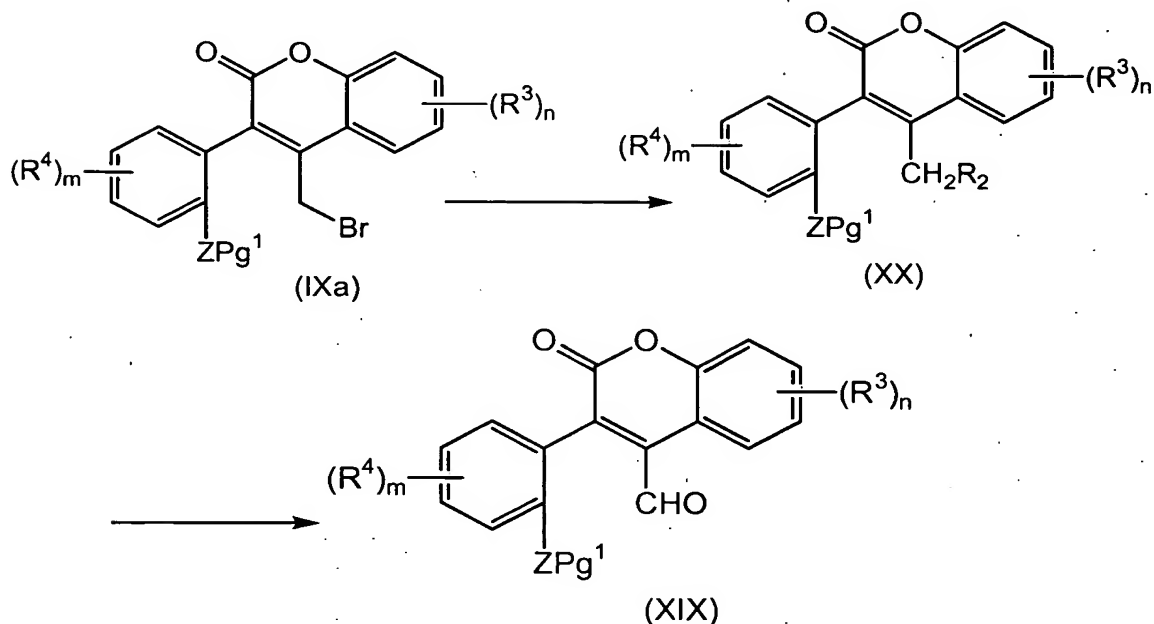
Scheme 5

Accordingly, a suitably substituted compound of formula (XVII), wherein Pg<sup>2</sup> is a suitable protecting group such as benzyloxy, methoxy, SEM, MOM, acetoxy, and the like, a known compound or compound prepared by known methods is reacted with an oxidizing agent such as SeO<sub>2</sub>, PCC, PDC, and the like, in an organic solvent such as toluene, xylene, ethyl acetate, dichloromethane, and the like, to yield the corresponding compound of formula (XVIII).

The compound of formula (XVIII) is further oxidized with an oxidizing agent such as SeO<sub>2</sub>, PCC, PDC, and the like, in an organic solvent such as toluene, xylene, ethyl acetate, dichloromethane, and the like, to yield the corresponding compound of formula (XIX).

One skilled in the art will recognize that when the compound of formula (XVII) is reacted with 2 or more equivalents of the oxidizing agent, the compound of formula (XVII) is converted directly to the compound of formula (XIX) (i.e. The intermediate alcohol compound of formula (XVIII) need not be isolated).

Alternatively, the compound of formula (XIX) may be prepared according to the process outlined in Scheme 6.

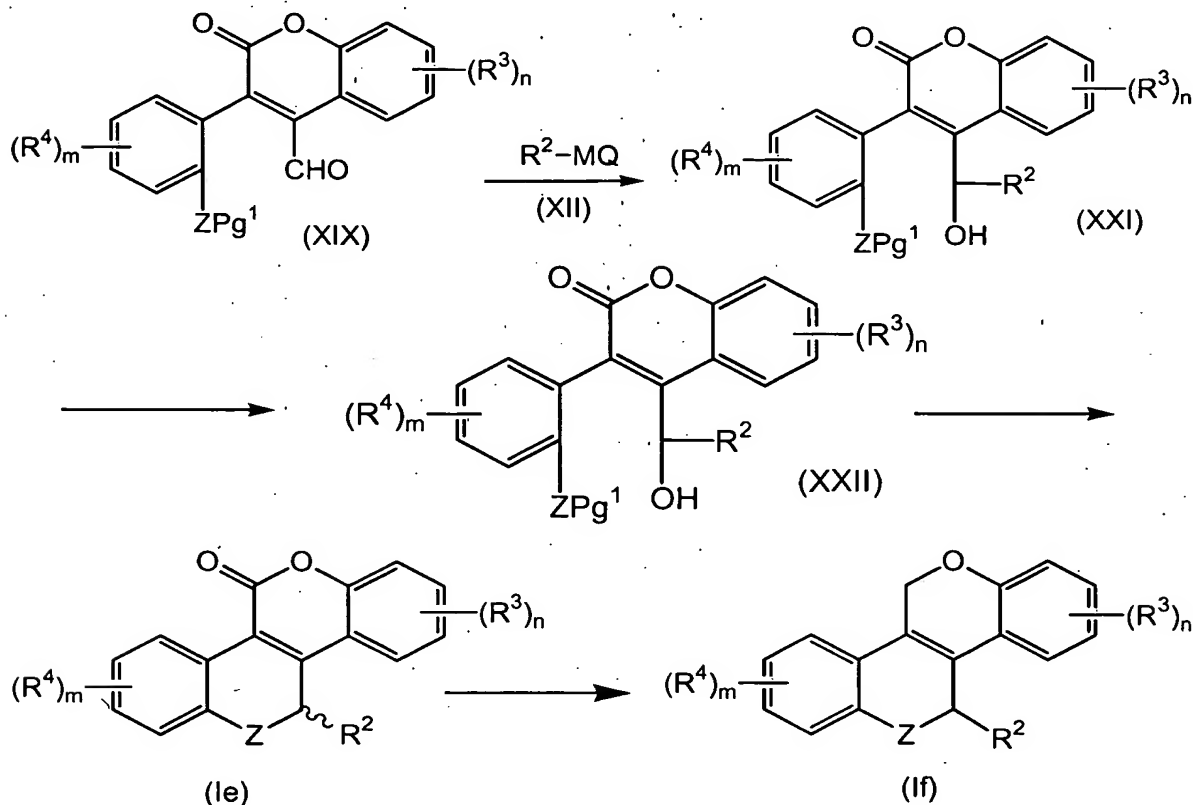


Scheme 6

Accordingly, a suitably substituted compound of formula (IXa), a compound of formula (IX) wherein  $R^A$  and  $R^B$  are each hydrogen, wherein Z is O and wherein  $Pg^1$  is a suitable protecting group such as benzyloxy, methoxy, SEM, MOM, acetoxy, and the like, a known compound or compound prepared by known methods is reacted with a radical brominating agent such as NBS,  $CBrCl_3$ ,  $NaBrO_3$  in combination with  $NaHSO_3$ , and the like or a radical chlorinating agent, such as NCS,  $SO_2Cl_2$ ,  $Cl_2$  gas, t-butyl hypochloride, and the like, preferably a radical brominating agent such as NBS, in the presence of a radical initiator such as benzoyl peroxide, AIBN, and the like and/or in the presence of a light source, such as a tungsten lamp, a 120 Watt light bulb, bright sunshine, and the like, optionally at an elevated temperature in the range of about  $50^\circ C$  to about  $120^\circ C$ , to yield the corresponding compound of formula (XX).

The compound of formula (XX) is hydrolyzed with water, in the presence of a base such as sodium carbonate, sodium bicarbonate, and the like, to yield the corresponding compound of formula (XIX).

Compounds of formula (I) wherein X is O, Y is CH<sub>2</sub> or C(O) and Z is O or S may be prepared from the intermediate compound of formula (XIX) according to the process outlined in Scheme 7.



Scheme 7

Accordingly, a compound of formula (XIX), is reacted with a suitably substituted compound of formula (XII), where MQ is lithium of a magnesium halide such as such as MgCl, MgBr or MgI, prepared from the corresponding known alkyl or aryl halide by known methods, in an organic solvent such as THF, diethyl ether, dioxane, hexane, and the like, to yield the corresponding compound of formula (XXI).

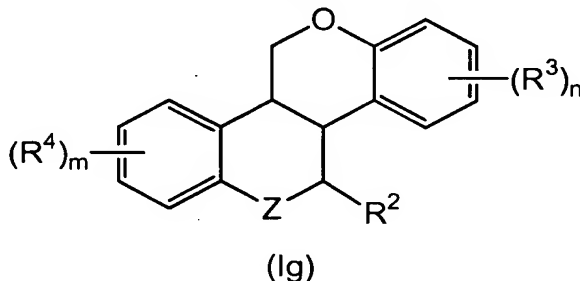
The compound of formula (XXI) is reacted with a protic acid such as HCl, H<sub>2</sub>SO<sub>4</sub>, p-toluene sulfonic acid, camphor sulfonic acid (CSA), TFA, and the like or a Lewis acid such as BF<sub>3</sub> etherate, AlCl<sub>3</sub>, SnCl<sub>4</sub>, and the like, in a solvent such as toluene, methylene chloride, acetonitrile and the like, to yield the corresponding compound of formula (Ie).

The compound of formula (Ie) may optionally be selectively reduced by reacting with a reducing agent such as LAH/AlCl<sub>3</sub>, and the like, in an organic

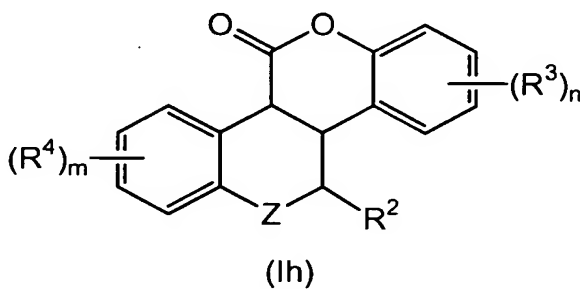
solvent such as THF, diethyl ether, dioxane, and the like, to yield the corresponding compound of formula (If).

One skilled in the art will recognize that it may be necessary and/or desirable to protect one or more of the  $R^3$  and/or  $R^4$  groups at any of the steps within the process described above. This may be accomplished using known protecting groups and know protection and de-protection reagents and conditions, for example such as those described in Protective Groups in Organic Chemistry, ed. J.F.W. McOmie, Plenum Press, 1973; and T.W. Greene & P.G.M. Wuts, Protective Groups in Organic Synthesis, John Wiley & Sons, 1991.

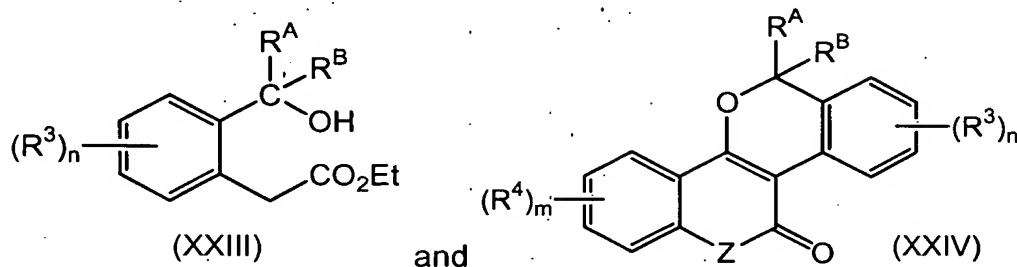
One skilled in the art will further recognize that the compounds of (Ie) and/or (If) may be optionally further selectively hydrogenated at the bridge bond of the B and C rings, as previously described, with protection of reactive groups as necessary, to yield the corresponding compound of formula (Ig).



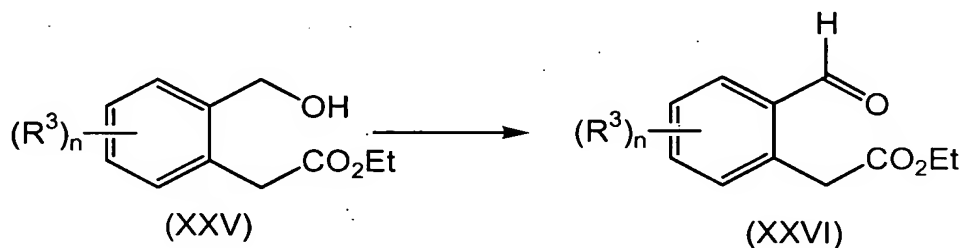
Alternatively, the compound of formula (XIX) may be substituted with the corresponding compound wherein the bridge bond of the B and C rings is fully saturated and then reacted according to the process outlined in Scheme 7, to yield the corresponding compound of formula (Ig) or (Ih).



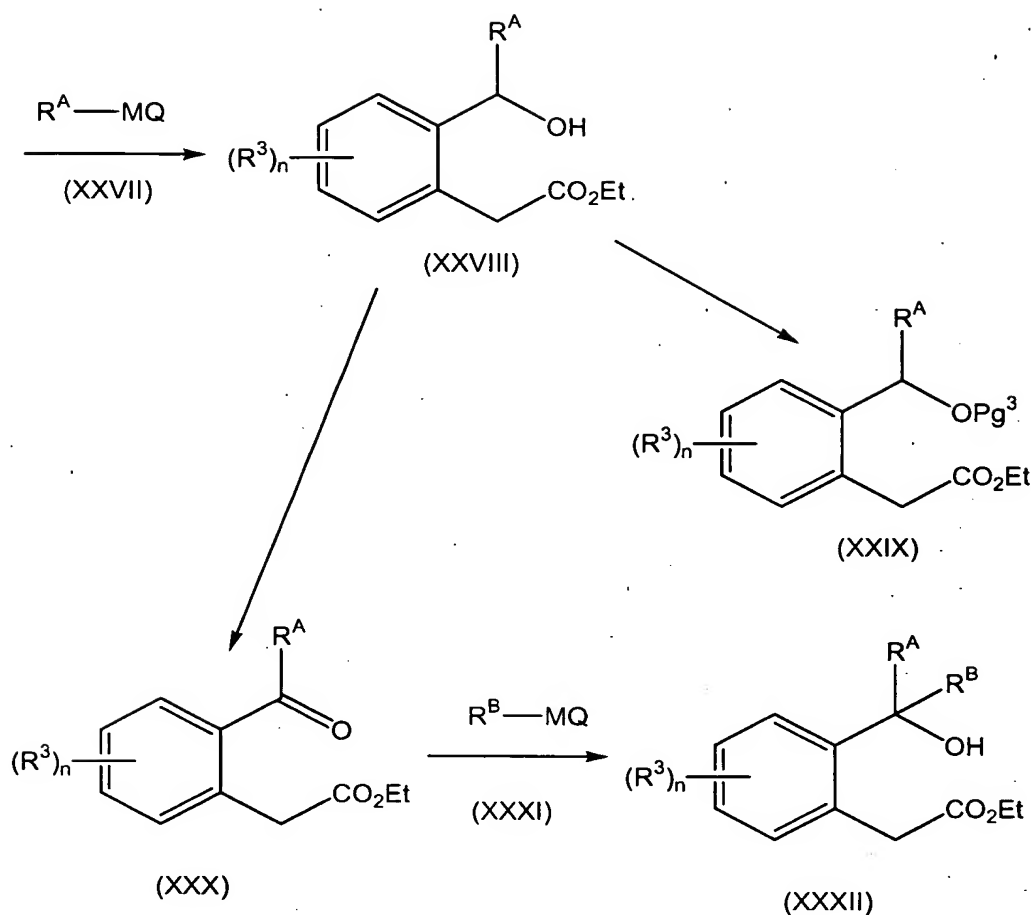
Compounds of formula (I) wherein X is  $CR^A R^B$ , Y is O and Z is O or S may be prepared via synthesis of intermediate compounds of formula (XXIII) and (XXIV)



- 5 which in turn may be prepared according to the processes outlined in Scheme 8 and 9. Accordingly, compounds of formula (XXIII) wherein one or both  $R^A$  and  $R^B$  are other than hydrogen may be prepared according to the process outlined in Scheme 8.







Scheme 8

Accordingly, a suitably substituted compound of formula (XXV) is reacted with an oxidizing agent such as  $MnO_2$ , PDC, TPAP, and the like, in an organic solvent such as DCM, acetonitrile, DCE, and the like, to yield the corresponding compound of formula (XXVI).

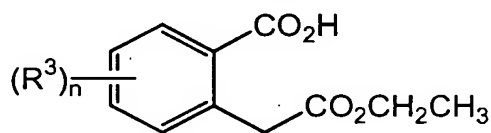
The compound of formula (XXVI) is reacted with a compound of formula (XXVII), wherein MQ is lithium or a magnesium halide such as  $MgCl$ ,  $MgBr$  or  $MgI$ , prepared from the corresponding known alkyl or aryl halide by known methods, in an organic solvent such as THF, diethyl ether, dioxane, hexane, and the like, to yield the corresponding compound of formula (XXVIII).

The compound of formula (XXVIII) is protected by reacting with a suitable protecting group, via known chemistry, to yield the corresponding compound of formula (XXIX), wherein  $Pg^3$  is a suitable protecting group such as benzyloxy, methoxy, MOM, SEM, and the like.

Alternatively, the compound of formula (XXVIII) is reacted with an oxidizing agent such as  $\text{MnO}_2$ , PDC, TPAP, and the like, in an organic solvent such as DCE, DCM, acetonitrile, and the like, to yield the corresponding compound of formula (XXX).

- 5           The compound of formula (XXX) is reacted with a suitably substituted compound of the formula (XXXI), wherein MQ is lithium or a magnesium halide such as  $\text{MgCl}$ ,  $\text{MgBr}$  or  $\text{MgI}$ , prepared from the corresponding known alkyl or aryl halide by known methods, in an organic solvent such as THF, diethyl ether, dioxane, hexane, and the like, to yield the corresponding compound of formula
- 10       (XXXII).

Compounds of formula (XXIII) wherein  $\text{R}^{\text{A}}$  and  $\text{R}^{\text{B}}$  are each hydrogen, (i.e. compounds of formula (XXV)) may be prepared by reducing a suitably substituted compound of the formula (XXXIII)



15

(XXXIII)

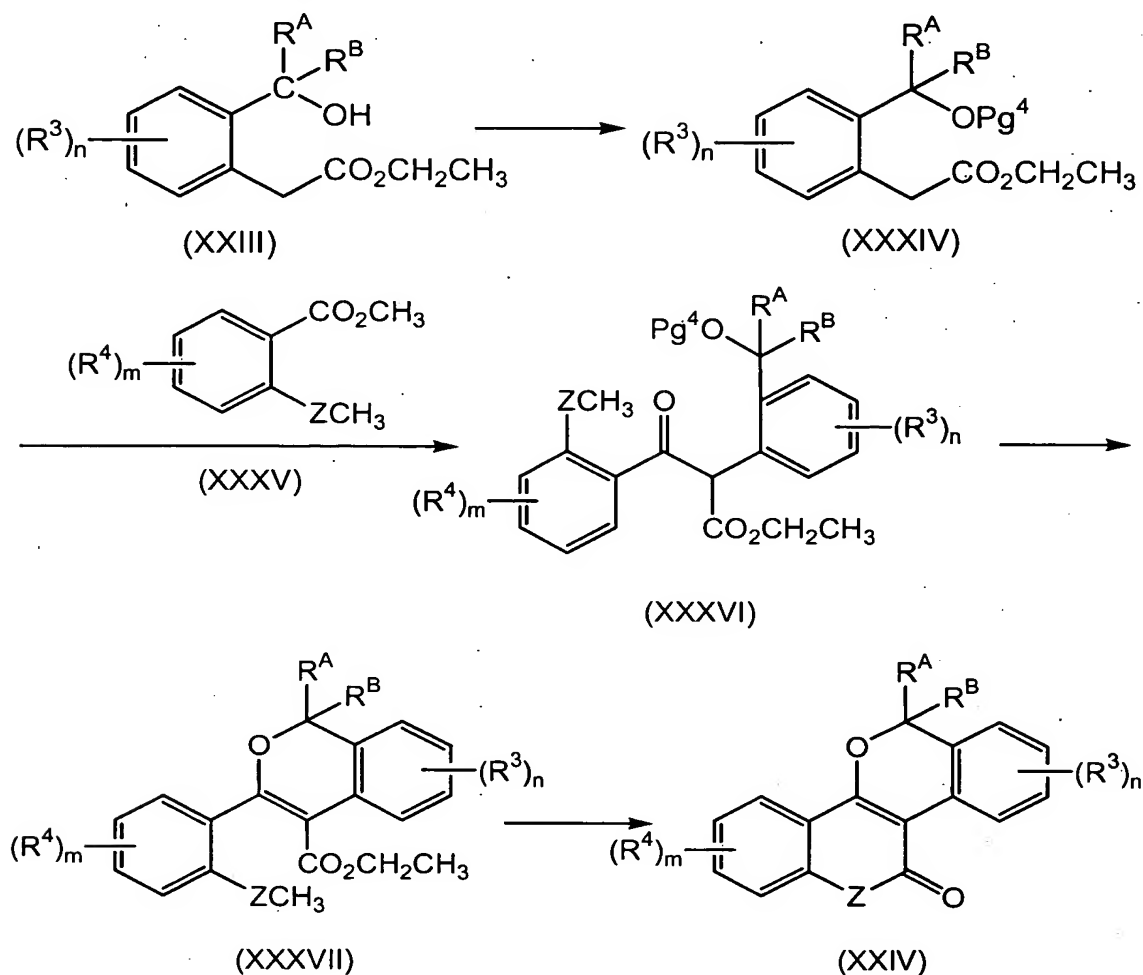
- in a two step process. Accordingly, the compound of formula (XXXIII) is reacted with oxalyl chloride, in an organic solvent such as THF, DCM, and the like, and then reacted with a reducing agent such as sodium borohydride, and the like, in an alcohol such as methanol, ethanol, and the like. Alternatively, the
- 20       compound of formula (XXXIII) is reacted with an anhydride such as acetic anhydride, and the like, in an organic solvent such as THF, DCM, and the like, and then reacted with a reducing agent such as sodium borohydride, and the like, in an alcohol such as methanol, ethanol, and the like, to yield the corresponding compound of formula (XXIII).

25

Alternatively, the compound of formula (XXXIII) is converted to the corresponding compound of formula (XXV) by reacting the compound of formula (XXXIII) with borane THF complex, in an organic solvent such as THF,

and the like, at a reduced temperature in the range of about  $-78^{\circ}\text{C}$  to about room temperature.

The compound of formula (XXIV) may be prepared according to the process outlined in Scheme 9.



Scheme 9

Accordingly, a suitably substituted compound of formula (XXIII), a known compound or compound prepared by known methods, for example as in Scheme 8 above, is protected with a suitable protecting group, by known methods, to yield the corresponding compound of formula (XXXIV), wherein Pg<sup>4</sup> is a suitable protecting group such as benzyloxy, methoxy, SEM, MOM, and the like.

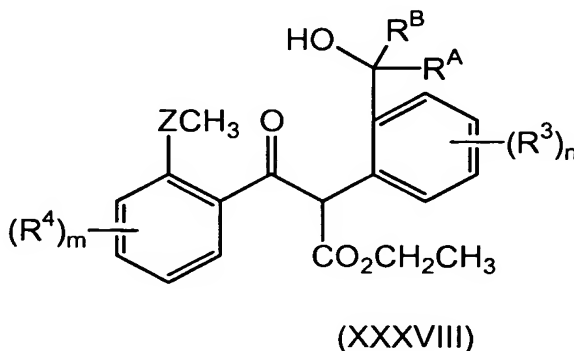
The compound of formula (XXXIV) is reacted with a suitably substituted compound of formula (XXXV), a known compound or compound prepared by known methods, in the presence of a base such as LDA, LHMDs, sodium hydride, and the like, in an organic solvent such as diethyl ether, THF, and the like, at a reduced temperature in the range of about -78°C to about 30°C, to yield the corresponding compound of formula (XXXVI).

The compound of formula (XXXVI) is de-protected by known methods, to yield the corresponding compound of formula (XXXVII).

The compound of formula (XXXVII) is reacted with a de-methylating reagent such as pyridine hydrochloride, pyridine hydrobromide, pyridine hydroiodide, and the like, optionally in an organic solvent such as xylene, acetic acid, and the like, at an elevated temperature in the range of about 170°C to about 220°C, to yield the corresponding compound of formula (XXIV).

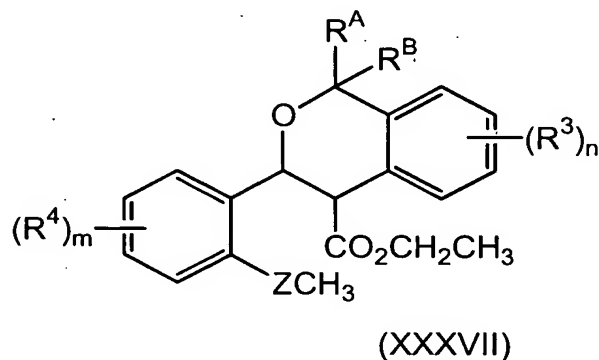
One skilled in the art will recognize that for preparation of compounds of formula (I) wherein one of  $R^A$  or  $R^B$  is hydrogen, the compound of formula (XXIX) may be substituted for the compound of formula (XXXIV) in the process outlined in Scheme 9.

One skilled in the art will further recognize that in the process outlined in Scheme 9, where the compound of formula (XXXVI) is de-protected to yield the compound of formula (XXXVII), it is possible that the compound of formula (XXXVI) does not fully convert to the compound of formula (XXXVII), but rather forms the intermediate compound of formula (XXXVIII).



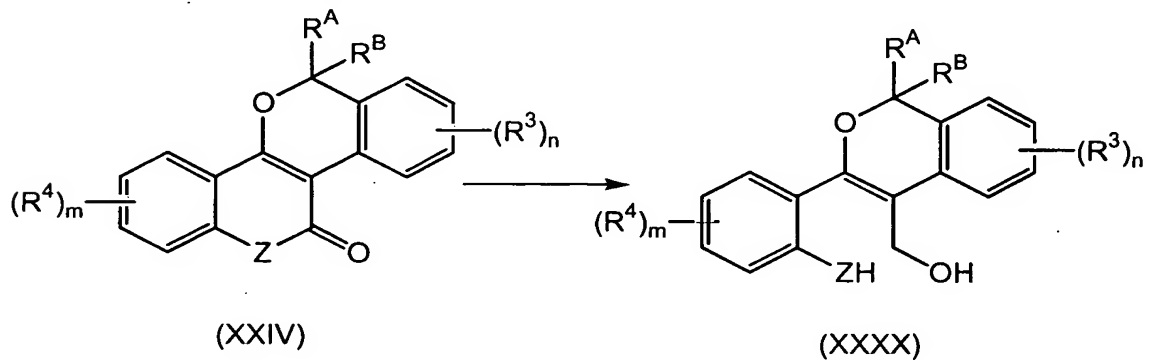
The compound of formula (XXXVIII) may then be converted to the compound of formula (XXXVII) according to known methods. For Example, wherein  $R^A$  and/or  $R^B$  is hydrogen, the compound of formula (XXXVIII) is reacted under Mitsunobu conditions to yield the corresponding compound of formula (XXXVII).

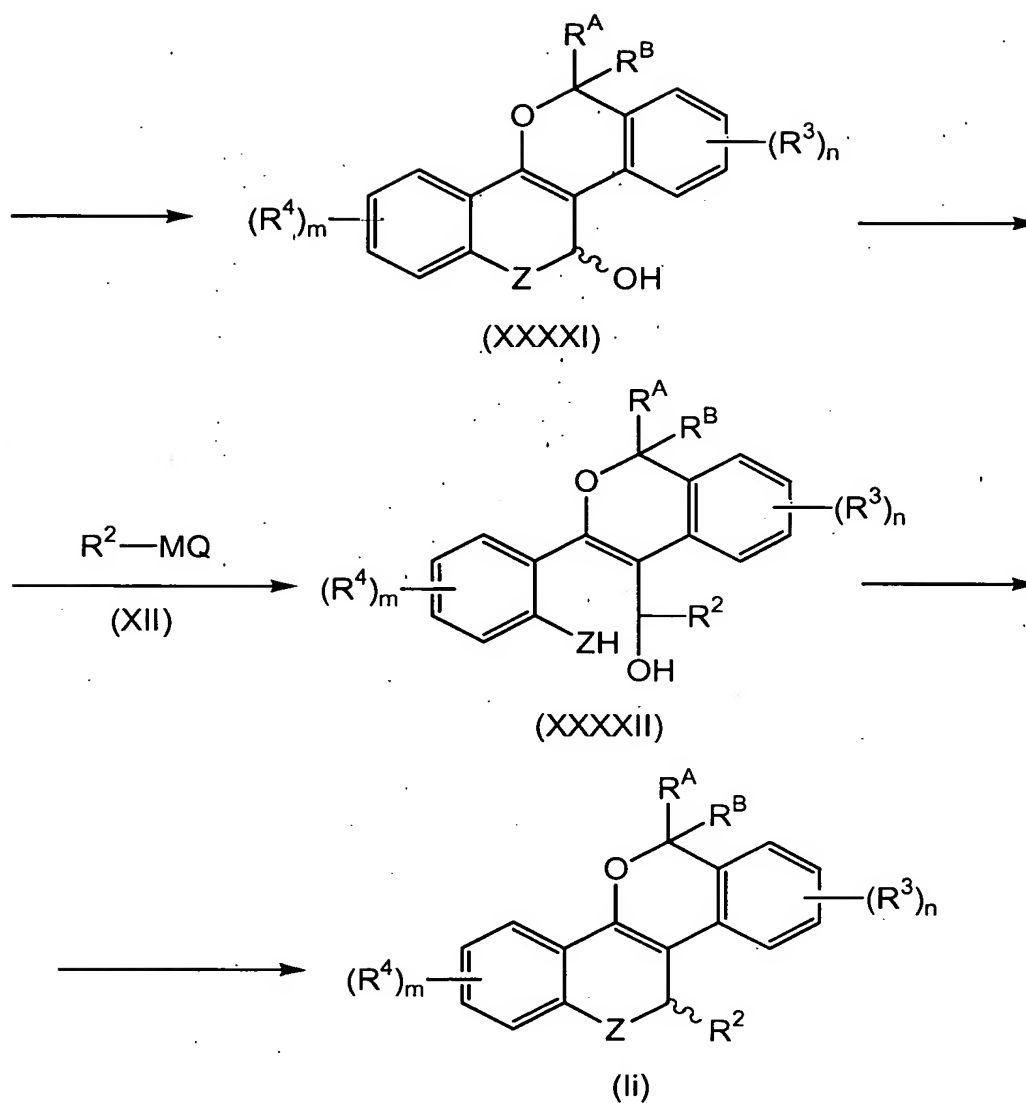
Alternatively, if both  $R^A$  and  $R^B$  are other than hydrogen, the compound of formula (XXXVIII) is reacted with an acid such as HCl, TsOH, PPTS, and the like, in an organic solvent or mixture such as THF, THF/H<sub>2</sub>O, dichloromethane, toluene/H<sub>2</sub>O, and the like, to yield the corresponding compound of formula (XXXVII).



which may be further converted to yield the desired compound of formula (I) according to the processes as herein described.

The compound of formula (XXIV) is then optionally, further substituted at the 5 position of the core structure, to yield the desired compound of formula (I), according to the process outlined in Scheme 10.





Scheme 10

5 More specifically, a suitably substituted compound of formula (XXIV) is reacted with a reducing agent such as diisobutyl aluminum hydride, LAH, and the like, in an organic solvent such as toluene, benzene, THF, and the like, at a reduced temperature in the range of about  $-50^{\circ}\text{C}$  to about  $-80^{\circ}\text{C}$ , to yield the corresponding compound of formula (XXXX).

10 The compound of formula (XXXX) is oxidized under oxidizing conditions such as Swern oxidation, Dess-Martin periodinane, TPAP, and the like, in an organic solvent such as dichloromethane, acetonitrile, DCE, and the like, to yield the corresponding compound of formula (XXXXI).

The compound of formula (XXXXI) is reacted with a suitably substituted compound of formula (XII), wherein MQ is lithium or a magnesium halide such as MgCl, MgBr or Mgl, prepared from the corresponding known alkyl or aryl halide by known methods, in an organic solvent such as THF, diethyl ether, dioxane, hexane, and the like, to yield the corresponding compound of formula (XXXXII).

The compound of formula (XXXXII) is treated with a reagent such as triphenylphosphine, tributylphosphine, and the like, and an azodicarboxamide such as DEAD, DIAD, and the like, in a solvent such as toluene, THF, and the like, to yield the corresponding compound of formula (Ii).

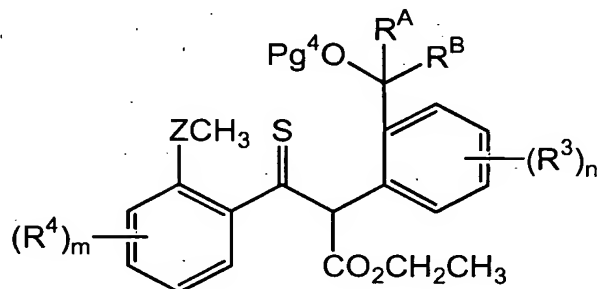
One skilled in the art will recognize that it may be necessary and/or desirable to protect one or more of the  $R^3$  and/or  $R^4$  groups at any of the steps within the process described above. This may be accomplished using known protecting groups and know protection and de-protection reagents and conditions, for example such as those described in Protective Groups in Organic Chemistry, ed. J.F.W. McOmie, Plenum Press, 1973; and T.W. Greene & P.G.M. Wuts, Protective Groups in Organic Synthesis, John Wiley & Sons, 1991.

Wherein the compound of formula (Ii) one or more  $R^3$  and / or  $R^4$  groups is hydroxy, the hydroxy groups may be optionally converted to desired groups according to the processes previously described, for example by reacting the compound of formula (Ii) with a suitably substituted acid chloride, a suitably substituted carboxylic acid or suitably substituted anhydride, as described in Scheme 4.

One skilled in the art will further recognize that the compound of formula (XXIV), the compound of formula (Ii) or the compound of formula (Ii) wherein any  $R^3$  and/or  $R^4$  hydroxy groups have been further functionalized may be selectively hydrogenated to yield the corresponding compound wherein the

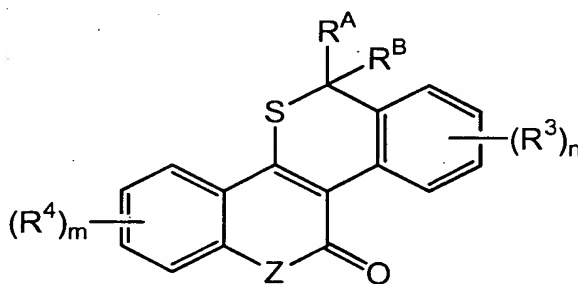
bond at the bridge of the B and C rings is fully saturated, according to the process as previously outlined.

- Compounds of formula (I) wherein X is  $\text{CR}^{\text{A}}\text{R}^{\text{B}}$  and Y is S may be prepared by modifying the processes outlined in Scheme 9 and 10. More particularly, the compound of formula (XXXVI), prepared as in Scheme 9, is reacted with a thionating reagent such as  $\text{CF}_3\text{SO}_3\text{Si}(\text{CH}_3)_3/(\text{CH}_3)_3\text{Si-S-Si}(\text{CH}_3)_3$ , and the like, in an organic solvent such as methylene chloride, chloroform, dichloromethane, and the like, to yield the corresponding compound of formula (XXXVIa).



(XXXVIa)

The compound of formula (XXXVIa) is then substituted for the compound of formula (XXXVI) and further reacted as described in Scheme 9, to yield the corresponding compound of formula (XXIVa),

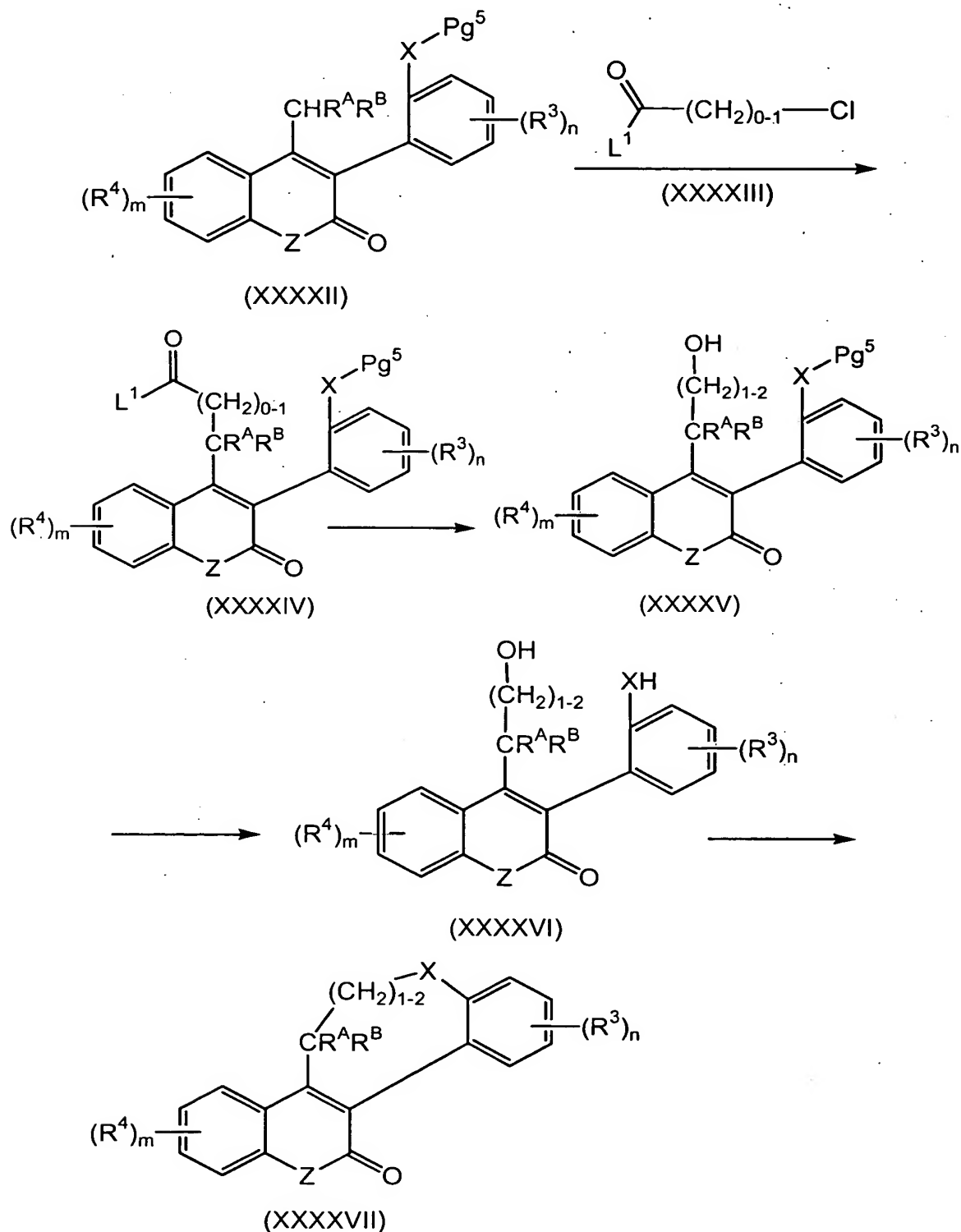


(XXIVa)

which is in turn substituted for the compound of formula (XXIV) in the process described in Scheme 10, to yield the corresponding compound of formula (I) wherein Y is S.



Compounds of formula (I) wherein X is O or S, Z is O or S and Y is  $-CR^A R^B CH_2-$  or  $-CR^A R^B CH_2 CH_2-$ , wherein  $R^A$  and  $R^B$  are not hydroxy, may be prepared according to the process outlined in Scheme 11.



## Scheme 11

More particularly, a suitably substituted compound of formula (XXXXII), where  $Pg^5$  is a suitable protecting groups such as alkyl (such as methyl), benzyl, SEM, MOM, BOM, pivaloyl, and the like; a known compound or  
 5 compound prepared by known methods, is reacted with a suitably substituted compound of formula (XXXXIII), wherein  $L^1$  is H or alkoxy, such as methoxy, ethoxy, and the like, in the presence of a base such as  $(TMS)_2NLi$ , LDA, NaHMDS, KHMDS, and the like, in the presence of a formylating reagent such as phenyl formate, 2,4,6-trichlorophenylformate,  $BrCH_2COOCH_3$ ,  
 10  $ClCH_2COOCH_3$ , and the like, in an organic solvent such as THF, diethyl ether, dioxane, and the like, to yield the corresponding compound of formula (XXXXIV).

The compound of formula (XXXXIV) is reacted with a reducing agent such as  $NaBH_4$ , borane, LAH, and the like, in an organic solvent such as THF,  
 15 diethyl ether, dioxane, and the like, to yield the corresponding compound of formula (XXXXV).

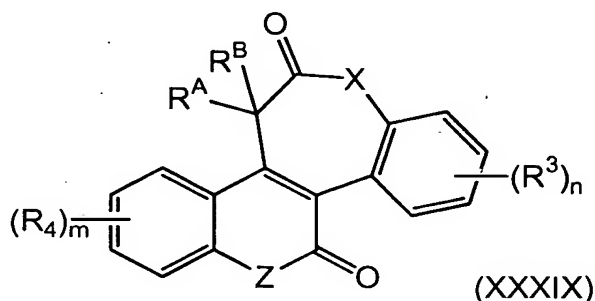
The compound of formula (XXXXV) is de-protected by known methods, to yield the corresponding compound of formula (XXXXVI).

The compound of formula (XXXXVI) is treated with a protic acid such as  
 20 HCl,  $H_2SO_4$ , p-toluene sulfonic acid, camphor sulfonic acid (CSA), TFA, and the like or a Lewis acid such as  $BF_3$  etherate,  $AlCl_3$ ,  $SnCl_4$ , and the like, in a solvent such as toluene, methylene chloride, acetonitrile and the like, to yield the corresponding compound of formula (XXXVII).

Alternatively, the compound of formula (XXXXVI) is treated with a  
 25 reagent such as triphenylphosphine, tributylphosphine, and the like, or an azodicarboxamide such as DEAD, DIAD, and the like, in a solvent such as toluene, THF, and the like, to yield the corresponding compound of formula (XXXXVII).

30 Compounds of formula (I) wherein X is selected from O, Y is  $CR^A R^B C(O)$  and Z is O or S may be prepared by reacting a suitably substituted compound of formula (XXXXIV) wherein  $L^1$  is phenoxy and wherein  $Pg^5$  is SEM or MOM,

with an acid such as hydrochloric acid, H<sub>2</sub>SO<sub>4</sub>, TFA, and the like, in an organic solvent such as isopropanol, THF, or a mixture thereof such as isopropanol:THF, and the like to yield the corresponding compound of formula (XXXIX).



The compound of formula (XXXIX) is then further reacted to yield the desired compound of formula (I) according to the processes described herein.

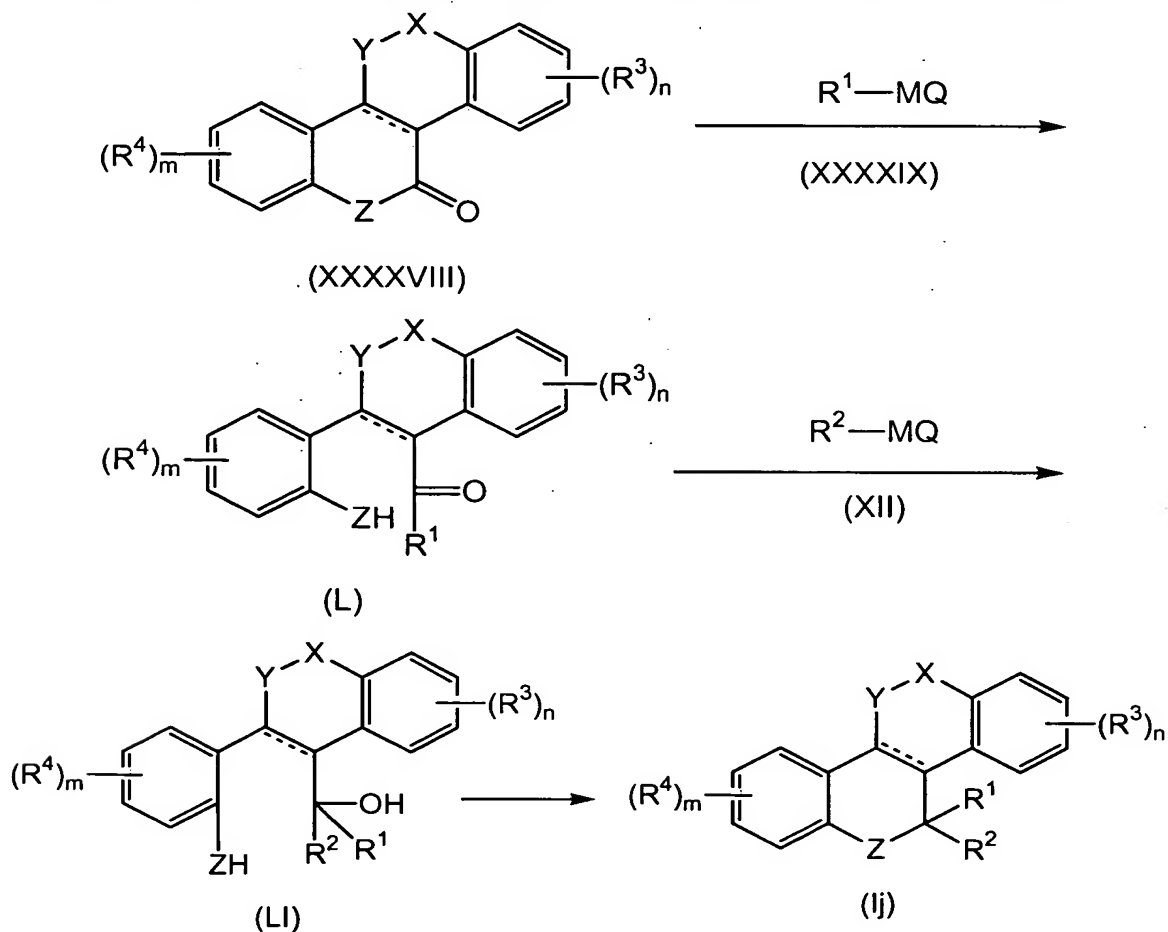
One skilled in the art will recognize that the compound of formula (XXXXVII) may be further reacted to the corresponding compound of formula (I) or (II) according to the processes previously described. For example, by substituting the compound of formula (XXXXVII) for the compound of formula (II) in Scheme 2 or 3, or substituting the compound of formula (XXXXVII) for the compound of formula (XXIV) in Scheme 10.

One skilled in the art will recognize that it may be necessary and/or desirable to protect one or more of the R<sup>3</sup> and/or R<sup>4</sup> groups at any of the steps within the process described above. This may be accomplished using known protecting groups and know protection and de-protection reagents and conditions, for example such as those described in Protective Groups in Organic Chemistry, ed. J.F.W. McOmie, Plenum Press, 1973; and T.W. Greene & P.G.M. Wuts, Protective Groups in Organic Synthesis, John Wiley & Sons, 1991.

One skilled in the art will further recognize that wherein one or more R<sup>3</sup> and/or R<sup>4</sup> groups are hydroxy, the hydroxy groups may be optionally converted to desired groups according to the processes previously described.

- One skilled in the art will further recognize that compounds of formula (I) wherein the bond at the bridge of the B and C rings is unsaturated (i.e. a double bond) may be converted to the corresponding compound of formula (I) wherein the bond at the bridge of the B and C rings is fully saturated (i.e. a single bond) as previously described, for example by selective hydrogenation, for example with hydrogen gas, with protection of reactive functional groups, as necessary. Alternatively, the bond at the bridge of the B and C rings may be selectively hydrogenated in any intermediate in the synthesis of the compound of formula (I) provided that reactive functional groups are suitably protected.

Compounds of formula (I) wherein  $R^1$  and  $R^2$  are each other than hydrogen may be prepared according to the process outlined in Scheme 12.



Scheme 12

Accordingly, a suitably substituted compound of formula (XXXXVIII), a known compound or compound prepared by known methods, for example according to the processes described herein, is reacted with a suitably substituted compound of formula (XXXXIX), wherein MQ is lithium or a magnesium halide such as MgCl, MgBr or MgI, prepared from the corresponding known alkyl or aryl halide by known methods, in an organic solvent such as THF, diethyl ether, dioxane, hexane, and the like, to yield the corresponding compound of formula (L).

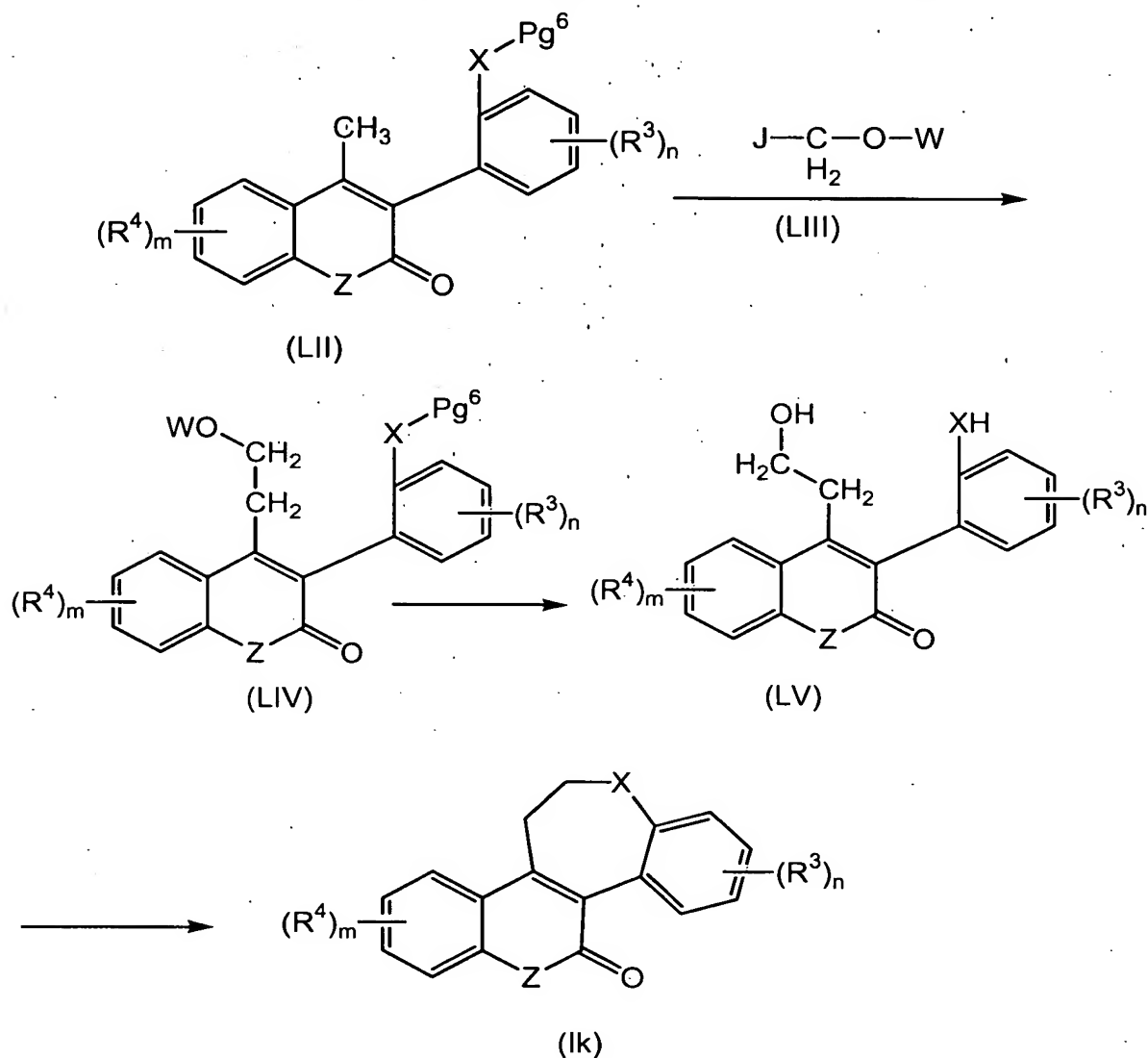
The compound of formula (L) is reacted with a suitably substituted compound of formula (XII), wherein MQ is lithium or a magnesium halide such as MgCl, MgBr or MgI, prepared from the corresponding known alkyl or aryl halide by known methods, in an organic solvent such as THF, diethyl ether, dioxane, hexane, and the like, to yield the corresponding compound of formula (LI).

The compound of formula (LI) is treated with a protic acid such as HCl, H<sub>2</sub>SO<sub>4</sub>, p-toluene sulfonic acid, camphor sulfonic acid (CSA), TFA, and the like or a Lewis acid such as BF<sub>3</sub> etherate, AlCl<sub>3</sub>, SnCl<sub>4</sub>, and the like, in a solvent such as toluene, methylene chloride, acetonitrile and the like, to yield the corresponding compound of formula (Ij).

Alternatively, the compound of formula (LI) is treated with a reagent such as triphenylphosphine, tributylphosphine, and the like, or an azodicarboamide such as DEAD, DIAD, and the like, in a solvent such as toluene, THF, and the like, to yield the corresponding compound of formula (Ij).

Compounds of formula (D) may be prepared from suitably substituted compounds of formula (VIII) wherein R<sup>3</sup> corresponds to R<sup>12</sup>, R<sup>4</sup> corresponds to R<sup>13</sup> and R<sup>A</sup> and R<sup>B</sup> are each hydrogen. More particularly, the compound of formula (VIII) is reacted with a strong base such as LDA, LiN(TMS)<sub>2</sub>, and the like, and then reacted with a suitably selected electrophile such as an alkyl aldehyde, an aryl aldehyde, an alkyl acid chloride, methylchloroformate, phenylchloroformate, α-chloroacetyl chloride, and the like, to yield the corresponding compound of formula (D).

Compounds of formula (I) wherein X is O or S, Z is O or S and Y is  $-\text{CH}_2\text{CH}_2-$ , may be prepared according to the process outlined in Scheme 13.



Scheme 13

More particularly, a suitably substituted compound of formula (LII) where Pg<sup>6</sup> is a suitable protecting groups such as benzyl, alkyl (such as methyl), SEM, MOM, BOM, substituted benzyl, PMB and the like, a known compound or compound prepared by known methods, is reacted with a suitably substituted compound of formula (LIII), wherein J is Cl, Br, iodide or another suitable leaving group, and W is a group such as alkyl (such as methyl, ethyl, and the like), benzyl,  $-\text{CH}_2\text{CH}_2\text{TMS}$ ,  $-\text{CH}_2\text{CH}_2\text{OCH}_3$ ,  $-\text{CH}_2\text{O}$ -benzyl, and the like, in the

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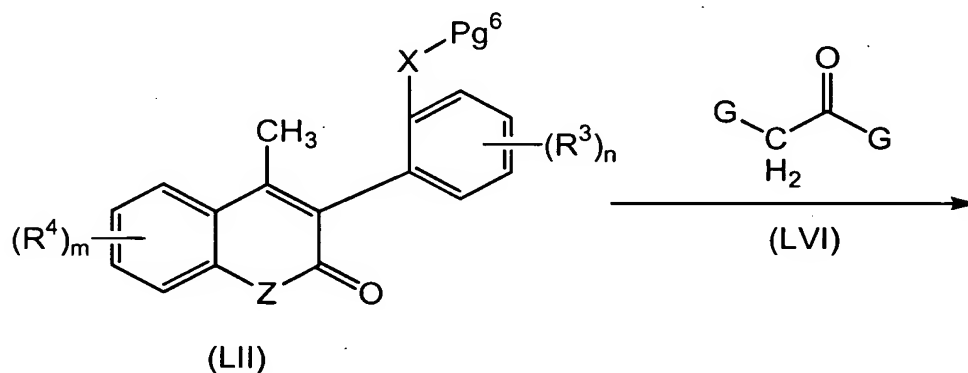
presence of a base such as  $(\text{TMS})_2\text{NLi}$ , LDA, NaHMDS, KHMDS, and the like, to yield the corresponding compound of formula (LIV).

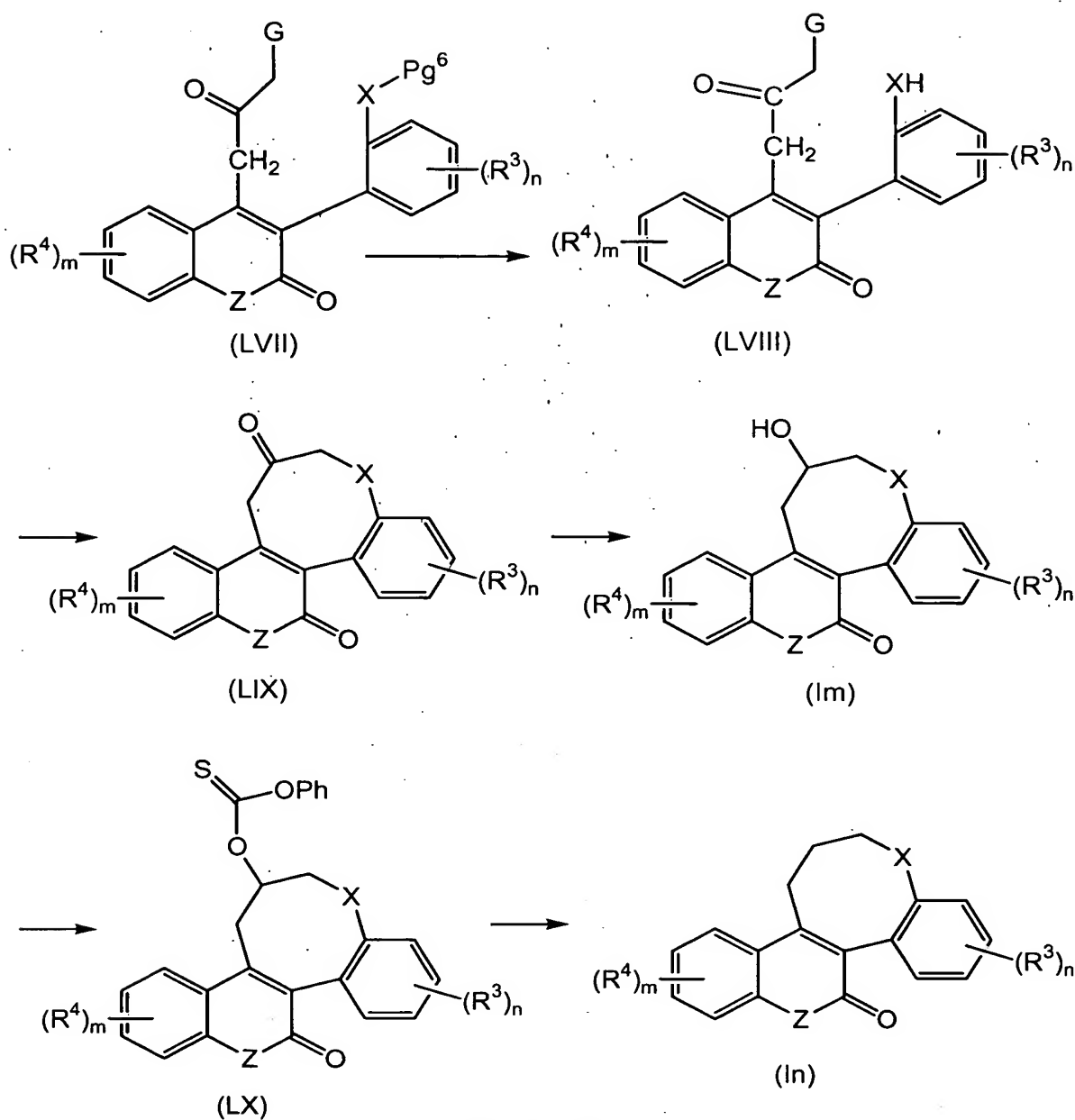
- 5 The compound of formula (LIV) is de-protected by known methods, for example by treating the compound of formula (LIV) with a protic such as HCl,  $\text{H}_2\text{SO}_4$ , TFA or with a Lewis acid such as  $\text{BCl}_3$ ,  $\text{BBr}_3$ ,  $\text{TiCl}_4$ ,  $\text{SnCl}_4$  or with a derivative of such a Lewis acid such catechol borane bromide, dimethyl borane bromide, and the like, to yield the corresponding compound of formula (LV).

- 10 The compound of formula (LV) is treated with a protic acid such as HCl,  $\text{H}_2\text{SO}_4$  and the like or with a Lewis acid such as  $\text{BF}_3$  etherate,  $\text{AlCl}_3$ ,  $\text{SnCl}_4$ ,  $\text{PCl}_3$ ,  $\text{POCl}_3$ ,  $\text{PCl}_5$  and the like, in a solvent such as toluene, methylene chloride, acetonitrile and the like, to yield the corresponding compound of formula (Ik).

- 15 Alternatively, the compound of formula (LV) is treated with a reagent such as triphenylphosphine, tributylphosphine, and the like, or with an azodicarboxamide such as DEAD, DIAD, and the like, in a solvent such as toluene, THF, and the like, to yield the corresponding compound of formula (Ik).

- 20 14. Compounds of formula (I) wherein X is O or S, Z is O or S and Y is  $-\text{CH}_2\text{CH}_2\text{CH}_2-$  may be prepared according to the process outlined in Scheme





5

Scheme 14

More particularly, a suitably substituted compound of formula (LII), where  $Pg^6$  is a suitable protecting groups such as benzyl, alkyl (such as methyl), SEM, MOM, BOM, substituted benzyl, PMB and the like, a known compound or compound prepared by known methods, is reacted with a suitably substituted compound of formula (LVI), wherein the two G groups are leaving groups, such as Cl, Br, Iodine, hydroxy, and the like, and wherein the two G groups are the same or different, a known compound or compound prepared by



known methods, in the presence of a base such as  $(\text{TMS})_2\text{NLi}$ , LDA, NaHMDS, KHMDS, and the like, to yield the corresponding compound of formula (LVII).

One skilled in the art will recognize that when the two G groups are different, they are selected such that the G group bound to the C(O) is more  
 5 reactive than the G group bound to the  $\text{CH}_2$  group.

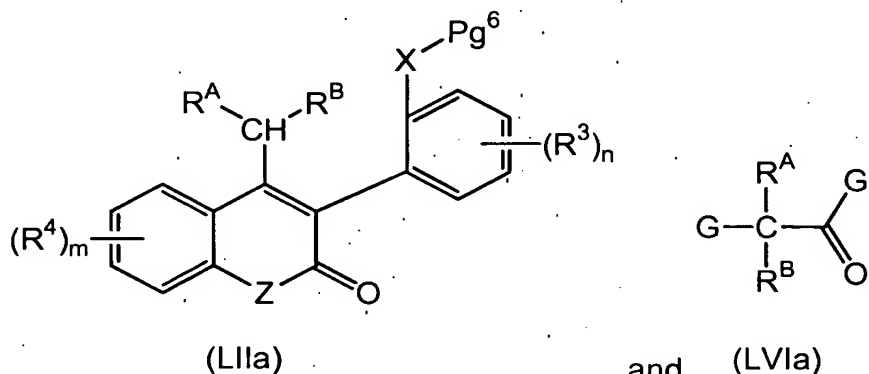
The compound of formula (LVII) is de-protected by known methods, for example by treating the compound of formula (LVII) with a protic acid such as HCl,  $\text{H}_2\text{SO}_4$ , TFA and the like, or with a Lewis acid such as  $\text{BCl}_3$ ,  $\text{BBr}_3$ ,  $\text{TiCl}_4$ ,  $\text{SnCl}_4$ , and the like or with a derivatives of a Lewis acid such as catechol  
 10 borane bromide, dimethy borane bromide, and the like, to yield the corresponding compound of formula (LVIII).

The compound of formula (LVIII) is treated with a base such as potassium carbonate, sodium carbonate, cesium carbonate, potassium hydroxide, sodium hydroxide, and the like, or with an alkali metal alkoxide such  
 15 as sodium ethoxide, sodium methoxide, sodium t-butoxide, potassium ethoxide, potassium methoxide, potassium t-butoxide, and the like, in a solvent such as methanol, ethanol, isopropanol, THF, and the like, or in a mixture of solvents thereof such as methanol:acetone, ethanol:acetone, methanol:acetonitrile, and the like, to yield the corresponding compound of formula (LIX).

20 The compound of formula (LIX) is reacted with a base such as  $\text{NaBH}_4$ , borane, LAH, and the like, in an organic solvent such as THF, diethyl ether, dioxane, and the like, to yield the corresponding compound of formula (Im).

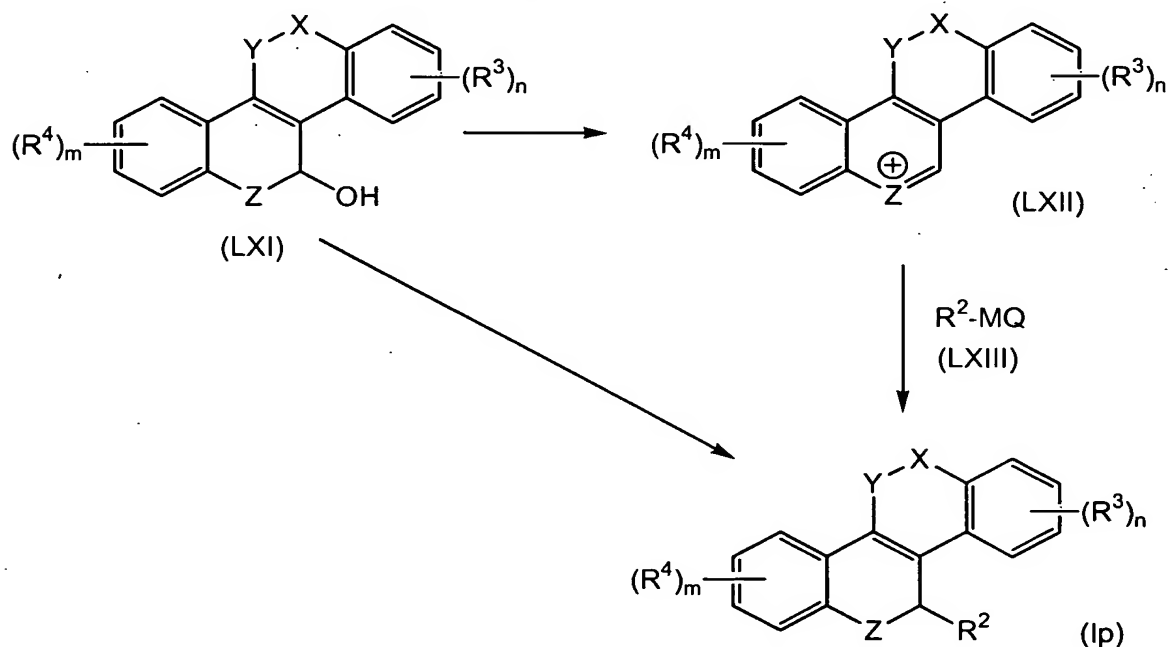
The compound of formula (Im) is deoxygenated using Barton or modified Barton protocol (see for example, K.C. Nicolaou, R.A. Daines, J. Uenishi, W.S.  
 25 Li, D.P. Papahatjis and T.K. Chakraborty, *J. Am. Chem. Soc.*, 1988, 110, pp. 4672-4683; which procedure involves conversion of the alcohol on the compound of formula (Im) to a thiocarbonate, as in the compound of formula (LX), followed by treatment with tributyltinhydride in presence of radical initiator like benzoyl peroxide, AIBN, and the like) to yield the corresponding compound  
 30 of formula (In).

One skilled in the art will recognize that compounds of formula (I) wherein X is O or S, Z is O or S and Y is  $-\text{CR}^{\text{A}}\text{R}^{\text{B}}-\text{CH}(\text{OH})-\text{CR}^{\text{A}}\text{R}^{\text{B}}-$  or  $-\text{CR}^{\text{A}}\text{R}^{\text{B}}-\text{CH}_2-\text{CR}^{\text{A}}\text{R}^{\text{B}}-$  may be similarly prepared according to the process outlined in Scheme 13 above, with substitution of a suitably substituted compound (LIIa) and (LVIIa)



for the corresponding compounds of formula (LII) and (LIII), respectively.

Compounds of formula (I) wherein X is O or S, Y is CR<sup>A</sup>R<sup>B</sup>, CH<sub>2</sub>CH<sub>2</sub> or  
10 CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub> and Z is O or S may be prepared from a suitably substituted  
compound of formula (xA) according to the process outlined in Scheme 15.



Scheme 15

Accordingly, a suitably substituted compound of formula (LXI), a known compound or compound prepared by known methods, is reacted with a Lewis acid such  $\text{BF}_3\text{OEt}_2$ ,  $\text{SnCl}_4$ ,  $\text{TiCl}_4$ , perchloric acid and like, in an organic solvent such as  $\text{CH}_2\text{Cl}_2$ ,  $\text{CHCl}_3$  and the like, to yield the corresponding, reactive

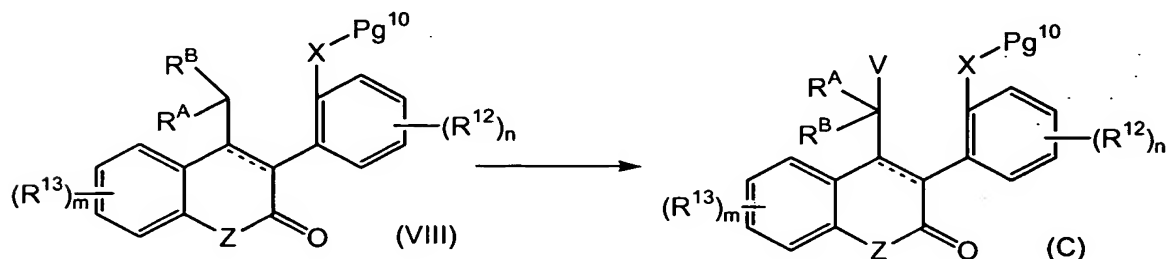
5 intermediate compound of formula (LXII).

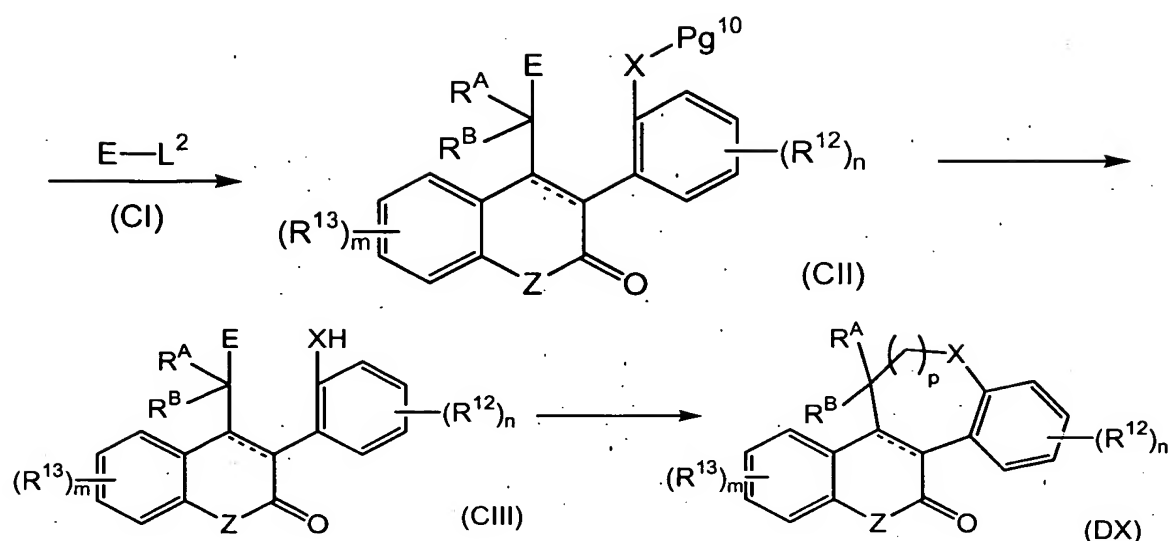
The compound of formula (LXII) is reacted with a suitably substituted compound of formula (LXIII), wherein MQ is a magnesium halide such as  $\text{MgCl}$ ,  $\text{MgBr}$  or  $\text{MgI}$  (which magnesium halide may be prepared from the corresponding known alkyl or aryl halide by known methods), in an organic  
10 solvent such as THF, diethyl ether, dioxane, hexane, and the like, to yield the corresponding compound of formula (Ip).

Alternatively, the compound of formula (LXI) is reacted with enol ether, or an allylic reagent such as 1,1-bis-trimethylsilyloxy-ethene, 1,1-bis-trimethylsilyloxy-propene, (1-methoxy-vinyloxy)-trimethyl-silane, allyl-trimethyl-silane, allyl-trimethyl-stannane, but-2-enyl-trimethyl-silane, but-2-enyl-trimethyl-stannane and trimethyl-vinyloxy-silane, and the like to yield the corresponding  
15 compound of formula (Ip).

One skilled in the art will further recognize that compounds of formula (I) where  
20 wherein Y is selected from the group consisting of  $\text{CR}^{\text{A}}\text{R}^{\text{B}}(\text{CR}^{\text{A}}\text{R}^{\text{B}})_{1-2}$  and  $\text{CR}^{\text{A}}\text{R}^{\text{B}}\text{C}(\text{O})\text{CR}^{\text{A}}\text{R}^{\text{B}}$  may be similarly prepared according to processes described herein, by selecting and substituting, suitably substituted reagents for those described herein.

25 The present invention is further directed to a process for the preparation of a compound of formula (DX), as described in more detail in Scheme 16.





Scheme 16

- Accordingly, a suitably substituted compound of formula (VIII), a known compound or compound prepared by known methods, wherein  $R^A$ ,  $R^B$ ,  $n$ ,  $R^3$ ,  $m$ ,  $R^4$  and  $Z$  are as previously defined, wherein  $X$  is O or S and wherein  $Pg^{10}$  is a suitable protecting group such as alkyl (such as methyl), benzyl, benzoyl, SEM, MOM, BOM, pivaloyl, and the like (see for example Protective Groups in Organic Chemistry, ed. J.F.W. McOmie, Plenum Press, 1973; and T.W. Greene & P.G.M. Wuts, Protective Groups in Organic Synthesis, John Wiley & Sons, 1991), is reacted with a base such as LiHMDS, LDA, KHMDS, NaHMDS, and the like; preferably at a temperature of less than or equal to about room temperature, more preferably at a temperature in the range of about 30°C to about -100°C, more preferably still, at reduced temperature in the range of about -10°C to about -30°C; in an aprotic organic solvent such as THF, dioxane, diethylether, and the like; to yield the corresponding compound of formula (C), wherein  $V$  is the corresponding base cation, Li, K or Na (i.e. when the base is LiHMDS or LDA,  $V$  is Li; when the base is KHMDS,  $V$  is K; when the base is NaHMDS,  $V$  is Na).
- The compound of formula (C) is reacted with a suitably substituted compound of formula (CI), wherein  $E$  is an electrophile (i.e. an atom or molecule capable of forming a carbon cation or partial carbon cation), such as Br, Cl, I,  $CH_3$ , SEM, MOM, BOM,  $Br-CH_2CH_2-OCH_3$ , and the like, and wherein

L<sup>2</sup> is a suitable leaving group such as Cl, Br, I, tosylate, mesylate, and the like, to yield the corresponding compound of formula (CII). The compound of formula (CI) may also be a source of Br or Cl such as NBS, NCS, and the like.

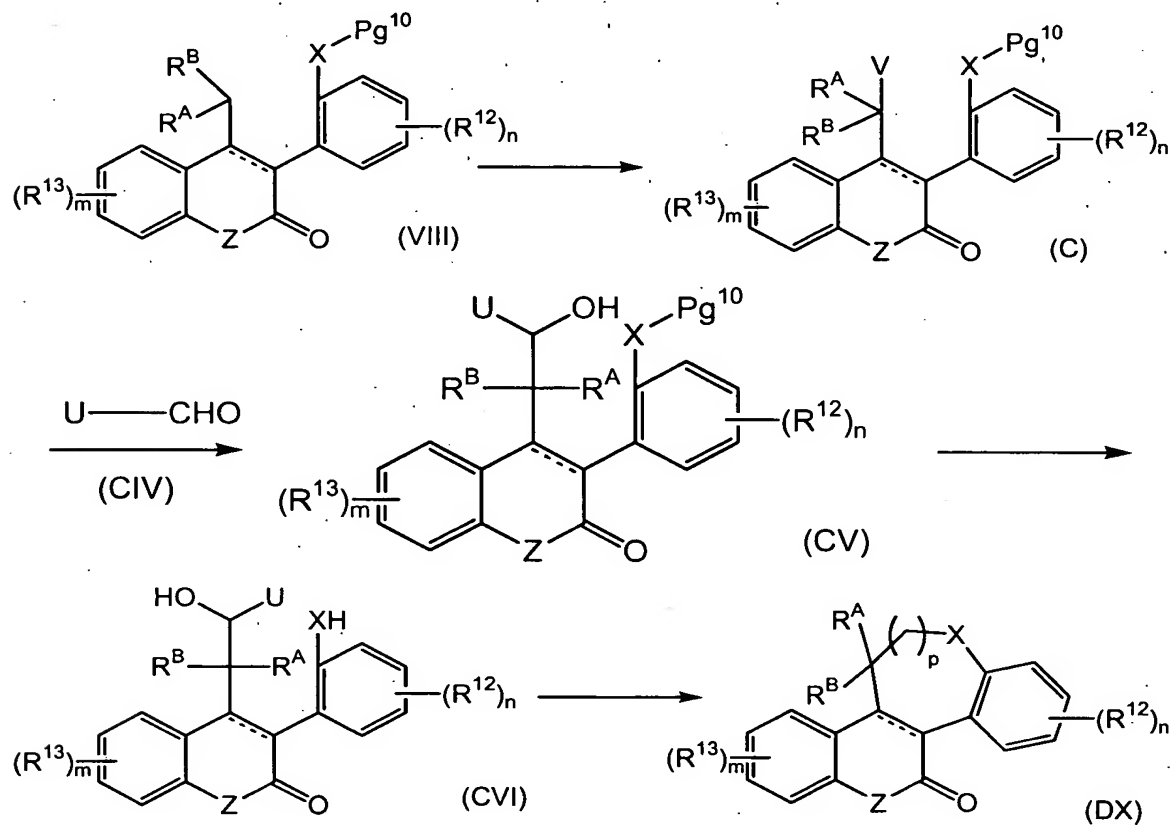
The compound of formula (CII) is de-protected by known methods  
 5 (Protective Groups in Organic Chemistry, ed. J.F.W. McOmie, Plenum Press, 1973; and T.W. Greene & P.G.M. Wuts, Protective Groups in Organic Synthesis, John Wiley & Sons, 1991), to yield the corresponding compound of formula (CIII).

The compound of formula (CIII) is cyclized according to known methods,  
 10 to yield the corresponding compound of formula (DX), wherein p is an integer from 0 to 2. When the electrophile E is Br, Cl, I and the like, the compound of formula (CIV) is treated with a base such as sodium carbonate, sodium bicarbonate, potassium carbonate, potassium bicarbonate, NaOH, KOH, TEA, and the like, preferably to a pH in the range of about pH10 to about pH11, to  
 15 yield the corresponding compound of formula DX, wherein p is 0. When the electrophile E is SEM, MOM, BOM, Br-CH<sub>2</sub>CH<sub>2</sub>-OCH<sub>3</sub>, and the like, the compound of formula (CIV) is reacted with a protic acid such as HCl, H<sub>2</sub>SO<sub>4</sub>, p-toluene sulfonic acid, camphor sulfonic acid (CSA), TFA, and the like or a Lewis acid such as BF<sub>3</sub> etherate, AlCl<sub>3</sub>, SnCl<sub>4</sub>, and the like, in a solvent such as  
 20 toluene, methylene chloride, acetonitrile and the like; or with a reagent such as triphenylphosphine, tributylphosphine, and the like, or an azodicarboamide such as DEAD, DIAD, and the like, in a solvent such as toluene, THF, and the like, to yield the corresponding compound of formula (DX), wherein p is 1-2.

25 One skilled in the art will recognize that the compound of formula (C) may alternatively be reacted with a suitably substituted compound of formula (CIa) wherein when the electrophile E is -C(O)CH<sub>2</sub>-OCH<sub>3</sub>, -C(O)-CH<sub>2</sub>-Cl, -C(O)-CH<sub>2</sub>-Br, -C(O)-CH<sub>2</sub>-(lower alkyl), -CH<sub>2</sub>-C(O)O-(lower alkyl), to yield the corresponding compound of formula (CII) which is then further reacted with a  
 30 protic acid such as HCl, H<sub>2</sub>SO<sub>4</sub>, p-toluene sulfonic acid, camphor sulfonic acid (CSA), TFA, and the like or a Lewis acid such as BF<sub>3</sub> etherate, AlCl<sub>3</sub>, SnCl<sub>4</sub>, and the like, in a solvent such as toluene, methylene chloride, acetonitrile and

the like; or with a reagent such as triphenylphosphine, tributylphosphine, and the like, or an azodicarboamide such as DEAD, DIAD, and the like, in a solvent such as toluene, THF, and the like, to yield the corresponding compound of formula (DXa), wherein  $-(CH_2)_p-$  is substituted with  $-C(O)-CH_2$  wherein the  $CH_2$  portion is bound to the X.

The present invention is further directed to a process for the preparation of a compound of formula (DXI), as described in more detail in Scheme 17.



Scheme 17

Accordingly, a suitably substituted compound of formula (VIII), a known compound or compound prepared by known methods, wherein  $R^A$ ,  $R^B$ ,  $n$ ,  $R^3$ ,  $m$ ,  $R^4$  and  $Z$  are as previously defined, wherein  $X$  is O or S and wherein  $Pg^{10}$  is a suitable protecting group such as alkyl (such as methyl), benzyl, benzoyl, SEM, MOM, BOM, pivaloyl, and the like (see for example T.W. Greene & P.G.M. Wuts, Protective Groups in Organic Synthesis, John Wiley & Sons), is reacted with a base such as LiHMDS, LDA, KHMDS, NaHMDS, and the like;

preferably at a temperature of less than or equal to about room temperature, more preferably at a temperature in the range of about 30°C to about -100°C, more preferably still, at reduced temperature in the range of about -10 to about -30°C; in an aprotic organic solvent such as THF, dioxane, diethyether, and the like; to yield the corresponding compound of formula (C), wherein V is the corresponding base cation, Li, K or Na (i.e. when the base is LiHMDs or LDA, V is Li; when the base is KHMDS, V is K; when the base is NaHMDS, V is Na).

The compound of formula (C) is reacted with a suitably substituted compound of formula (C) is reacted with a suitably substituted aldehyde, a compound of formula (CIV), wherein U is hydrogen or lower alkyl, to yield the corresponding compound of formula (CV).

The compound of formula (CV) is de-protected by known methods (Protective Groups in Organic Chemistry, ed. J.F.W. McOmie, Plenum Press, 1973; and T.W. Greene & P.G.M. Wuts, Protective Groups in Organic Synthesis, John Wiley & Sons, 1991), to yield the corresponding compound of formula (CVI).

The compound of formula (CVI) is cyclized according to known methods, to yield the corresponding compound of formula (DX), wherein p is 1. More particularly, the compound of formula (CIV) is reacted with a protic acid such as HCl, H<sub>2</sub>SO<sub>4</sub>, p-toluene sulfonic acid, camphor sulfonic acid (CSA), TFA, and the like or a Lewis acid such as BF<sub>3</sub> etherate, AlCl<sub>3</sub>, SnCl<sub>4</sub>, and the like, in a solvent such as toluene, methylene chloride, acetonitrile and the like; or with a reagent such as triphenylphosphine, tributylphosphine, and the like, or an azodicarboamide such as DEAD, DIAD, and the like, in a solvent such as toluene, THF, and the like; to yield the corresponding compound of formula (DX), wherein p is 1.

Where the processes for the preparation of the compounds according to the invention give rise to mixture of stereoisomers, these isomers may be separated by conventional techniques such as preparative chromatography. The compounds may be prepared in racemic form, or individual enantiomers may be prepared either by enantiospecific synthesis or by resolution. The

compounds may, for example, be resolved into their component enantiomers by standard techniques, such as the formation of diastereomeric pairs by salt formation with an optically active acid, such as (-)-di-p-toluoyl-d-tartaric acid and/or (+)-di-p-toluoyl-l-tartaric acid followed by fractional crystallization and  
 5 regeneration of the free base. The compounds may also be resolved by formation of diastereomeric esters or amides, followed by chromatographic separation and removal of the chiral auxiliary. Alternatively, the compounds may be resolved using a chiral HPLC column.

10 During any of the processes for preparation of the compounds of the present invention, it may be necessary and/or desirable to protect sensitive or reactive groups on any of the molecules concerned. This may be achieved by means of conventional protecting groups, such as those described in Protective Groups in Organic Chemistry, ed. J.F.W. McOmie, Plenum Press, 1973; and  
 15 T.W. Greene & P.G.M. Wuts, Protective Groups in Organic Synthesis, John Wiley & Sons, 1991. The protecting groups may be removed at a convenient subsequent stage using methods known from the art.

The utility of the compounds of the instant invention to treat disorders  
 20 mediated by an estrogen receptor may be determined according to the procedures described in Examples -172, 173, 174 and 175 herein.

The present invention therefore provides a method of treating disorders mediated by an estrogen receptor in a subject in need thereof which comprises  
 25 administering any of the compounds as defined herein in a quantity effective to treat said disorder. The compound may be administered to a patient by any conventional route of administration, including, but not limited to, intravenous, oral, subcutaneous, intramuscular, intradermal and parenteral. The quantity of the compound which is effective for treating a disorder mediated by an  
 30 estrogen receptor is between 0.01 mg per kg and 20 mg per kg of subject body weight.



The present invention also provides pharmaceutical compositions comprising one or more compounds of this invention in association with a pharmaceutically acceptable carrier. Preferably these compositions are in unit dosage forms such as tablets, pills, capsules, powders, granules, sterile parenteral solutions or suspensions, metered aerosol or liquid sprays, drops, ampoules, autoinjector devices or suppositories; for oral parenteral, intranasal, sublingual or rectal administration, or for administration by inhalation or insufflation. Alternatively, the composition may be presented in a form suitable for once-weekly or once-monthly administration; for example, an insoluble salt of the active compound, such as the decanoate salt, may be adapted to provide a depot preparation for intramuscular injection. For preparing solid compositions such as tablets, the principal active ingredient is mixed with a pharmaceutical carrier, e.g. conventional tableting ingredients such as corn starch, lactose, sucrose, sorbitol, talc, stearic acid, magnesium stearate, dicalcium phosphate or gums, and other pharmaceutical diluents, e.g. water, to form a solid preformulation composition containing a homogeneous mixture of a compound of the present invention, or a pharmaceutically acceptable salt thereof. When referring to these preformulation compositions as homogeneous, it is meant that the active ingredient is dispersed evenly throughout the composition so that the composition may be readily subdivided into equally effective dosage forms such as tablets, pills and capsules. This solid preformulation composition is then subdivided into unit dosage forms of the type described above containing from 5 to about 1000 mg of the active ingredient of the present invention. The tablets or pills of the novel composition can be coated or otherwise compounded to provide a dosage form affording the advantage of prolonged action. For example, the tablet or pill can comprise an inner dosage and an outer dosage component, the latter being in the form of an envelope over the former. The two components can be separated by an enteric layer which serves to resist disintegration in the stomach and permits the inner component to pass intact into the duodenum or to be delayed in release. A variety of material can be used for such enteric

layers or coatings, such materials including a number of polymeric acids with such materials as shellac, cetyl alcohol and cellulose acetate.

The liquid forms in which the novel compositions of the present invention may be incorporated for administration orally or by injection include, aqueous solutions, suitably flavoured syrups, aqueous or oil suspensions, and flavoured emulsions with edible oils such as cottonseed oil, sesame oil, coconut oil or peanut oil, as well as elixirs and similar pharmaceutical vehicles. Suitable dispersing or suspending agents for aqueous suspensions, include synthetic and natural gums such as tragacanth, acacia, alginate, dextran, sodium carboxymethylcellulose, methylcellulose, polyvinyl-pyrrolidone or gelatin.

The method of treating a disorder mediated by an estrogen receptor described in the present invention may also be carried out using a pharmaceutical composition comprising any of the compounds as defined herein and a pharmaceutically acceptable carrier. The pharmaceutical composition may contain between about 5 mg and 1000 mg, preferably about 10 to 500 mg, of the compound, and may be constituted into any form suitable for the mode of administration selected. Carriers include necessary and inert pharmaceutical excipients, including, but not limited to, binders, suspending agents, lubricants, flavorants, sweeteners, preservatives, dyes, and coatings. Compositions suitable for oral administration include solid forms, such as pills, tablets, caplets, capsules (each including immediate release, timed release and sustained release formulations), granules, and powders, and liquid forms, such as solutions, syrups, elixirs, emulsions, and suspensions. Forms useful for parenteral administration include sterile solutions, emulsions and suspensions.

Advantageously, compounds of the present invention may be administered in a single daily dose, or the total daily dosage may be administered in divided doses of two, three or four times daily. Furthermore, compounds for the present invention can be administered in intranasal form via topical use of suitable intranasal vehicles, or via transdermal skin patches well known to those of

ordinary skill in that art. To be administered in the form of a transdermal delivery system, the dosage administration will, of course, be continuous rather than intermittent throughout the dosage regimen.

5           For instance, for oral administration in the form of a tablet or capsule, the active drug component can be combined with an oral, non-toxic pharmaceutically acceptable inert carrier such as ethanol, glycerol, water and the like. Moreover, when desired or necessary, suitable binders, lubricants, disintegrating agents and coloring agents can also be incorporated into the mixture. Suitable binders  
10 include, without limitation, starch, gelatin, natural sugars such as glucose or beta-lactose, corn sweeteners, natural and synthetic gums such as acacia, tragacanth or sodium oleate, sodium stearate, magnesium stearate, sodium benzoate, sodium acetate, sodium chloride and the like. Disintegrators include, without limitation, starch, methyl cellulose, agar, bentonite, xanthan gum and the like.

15

          The liquid forms may include suitably flavored suspending or dispersing agents such as the synthetic and natural gums, for example, tragacanth, acacia, methyl-cellulose and the like. For parenteral administration, sterile suspensions and solutions are desired. Isotonic preparations which generally contain suitable  
20 preservatives are employed when intravenous administration is desired.

          The compound of the present invention can also be administered in the form of liposome delivery systems, such as small unilamellar vesicles, large unilamellar vesicles, and multilamellar vesicles. Liposomes can be formed from a  
25 variety of phospholipids, such as cholesterol, stearylamine or phosphatidylcholines.

          Compounds of the present invention may also be delivered by the use of monoclonal antibodies as individual carriers to which the compound molecules  
30 are coupled. The compounds of the present invention may also be coupled with soluble polymers as targetable drug carriers. Such polymers can include polyvinylpyrrolidone, pyran copolymer, polyhydroxypropylmethacrylamidephenol,

polyhydroxyethylaspartamidophenol, or polyethyl-eneoxidepolylysine substituted with palmitoyl residue. Furthermore, the compounds of the present invention may be coupled to a class of biodegradable polymers useful in achieving controlled release of a drug, for example, polylactic acid, polyepsilon caprolactone, 5 polyhydroxy butyric acid, polyorthoesters, polyacetals, polydihydropyrans, polycyanoacrylates and cross-linked or amphipathic block copolymers of hydrogels.

10 Compounds of this invention may be administered in any of the foregoing compositions and according to dosage regimens established in the art whenever treatment of a disorder mediated by an estrogen receptor is required.

The daily dosage of the products may be varied over a wide range from about 1 to about 1,000 mg per adult human per day. For oral administration, the 15 compositions are preferably provided in the form of tablets containing, 1.0, 5.0, 10.0, 15.0, 25.0, 50.0, 100, 250 and 500 milligrams of the active ingredient for the symptomatic adjustment of the dosage to the patient to be treated. An effective amount of the drug is ordinarily supplied at a dosage level of from about 0.01 mg/kg to about 20 mg/kg of body weight per day. Preferably, the range is from 20 about 0.1 mg/kg to about 10 mg/kg of body weight per day, and especially from about 0.5 mg/kg to about 10 mg/kg of body weight per day. The compounds may be administered on a regimen of 1 to 4 times per day.

Optimal dosages to be administered may be readily determined by those 25 skilled in the art, and will vary with the particular compound used, the mode of administration, the strength of the preparation, the mode of administration, and the advancement of the disease condition. In addition, factors associated with the particular patient being treated, including patient age, weight, diet and time of administration, will result in the need to adjust dosages.

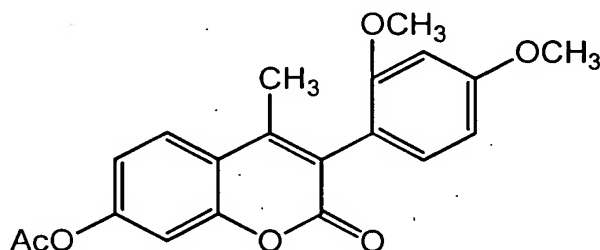
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The following Examples are set forth to aid in the understanding of the invention, and are not intended and should not be construed to limit in any way the invention set forth in the claims which follow thereafter.

5

**EXAMPLE 1**

**Acetic acid 3-(2,4-dimethoxyphenyl)-7-hydroxy-4-methyl-2-oxo-2H-chromen-7-yl ester**



A mixture of 2,4-dihydroxyacetophenone (2.233 g, 14.67mmol, 1 eq), 2, 4-dimethoxyphenylacetic acid (2.88 g, 14.67 mmol, 1 eq), acetic anhydride (7.5 mL, 78 mmol, 5 eq) and triethylamine (1.49 mL, 2.05 mmol, 1 eq) was stirred and heated to reflux under nitrogen for 48 hours. After cooling to room temperature the dark syrupy reaction mixture was poured into ice water (~450 mL). The suspension of sticky, semisolid product was neutralized by slowly adding solid NaHCO<sub>3</sub> to the mixture. The mixture was then allowed to solidify overnight. The dark solid was isolated by filtration, washed with water, sucked dry, and recrystallized from acetic acid to yield the title compound as an ivory crystalline solid. A second crop (0.95g, 18.3%) was isolated from the mother liquor.

20

mp: 146-148°C

MS (CI) m/z 355 (M+H)<sup>+</sup>

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.67 (1H, d, J = 8.7 Hz), 7.13 - 7.06 (3H, m), 6.58 (1H, d, J = 12.3 Hz), 6.56 (1H, s), 3.85 (3H, s), 3.76 (3H, s), 2.36 (3H, s), 2.24 (3H, s)

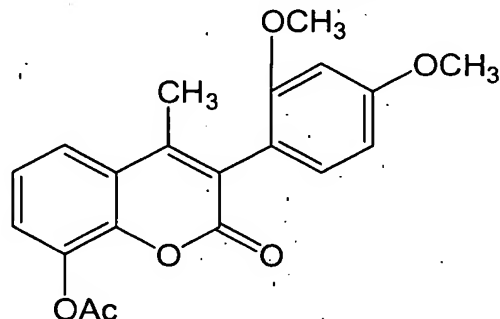
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IR (KBr): 1762, 1731, 1610, 1574, 1506, 1462, 1312, 1264, 1212 cm<sup>-1</sup>

Anal. Calc C<sub>20</sub>H<sub>18</sub>O<sub>6</sub>: C, 67.79; H, 5.12. Found: C, 67.75; H, 4.99.

**EXAMPLE 2**

**Acetic acid 3-(2,4-dimethoxyphenyl)-8-hydroxy-4-methyl-2-oxo-2H-chromen-7-yl ester**



- 5 The title compound was prepared according to the procedure described in Example 1 with substitution of 2,3 dihydroxyacetophenone for the 2,4-dihydroxyacetophenone reagent.

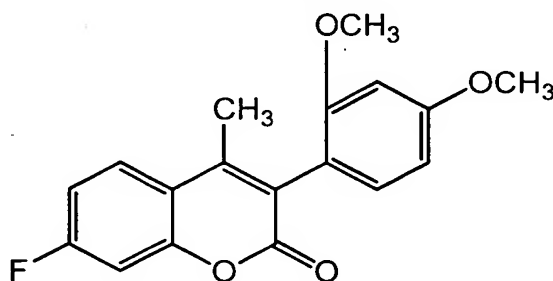
mp 140-141°C

MS (CI) m/z 355, (M+H)<sup>+</sup>, 377 (M+Na)<sup>+</sup>

- 10 <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.55 (1H, d, d, J = 4.2, 5.32 Hz), 7.29 (1H, d, J = 1.29 Hz), 7.27 (1H, d, J = 4.37 Hz), 7.08 (1H, d, J = 8.13 Hz), 6.57 – 6.55 (2H, m), 3.86 (3H, s), 3.76 (3H, s), 2.43 (3H, s), 2.24 (3H, s).

**EXAMPLE 3**

- 15 **3-(2,4-Dimethoxyphenyl)-7-fluoro-4-methyl-2-oxo-2H-chromen-7-yl ester**



- The title compound was prepared according to the procedure described in Example 1 with substitution of 4-fluoro-2-hydroxyacetophenone for the 2,4-dihydroxyacetophenone reagent.

- 20 mp 156-157°C

MS (CI) m/z 315 (M+H)<sup>+</sup>, 337 (M+Na)<sup>+</sup>

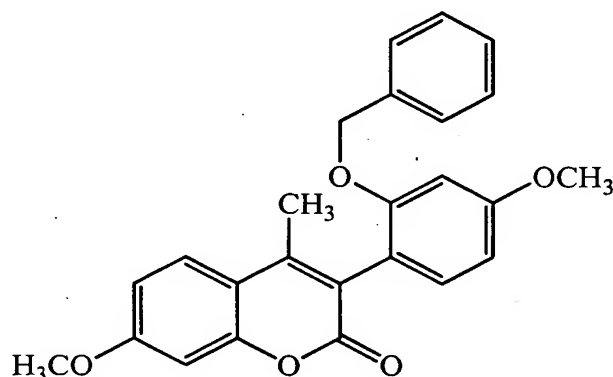
$^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.64 (1H, d, d,  $J$  = 5.98, 8.77 Hz), 7.11 – 7.01 (3H, m), 6.58 (1H, d, d,  $J$  = 2.30, 8.10 Hz), 6.57 (1H, s), 3.86 (3H, s), 3.77 (3H, s), 2.24 (3H, s)

IR (KBr): 1712, 1617, 1527, 1505, 1215, 1118  $\text{cm}^{-1}$

5 Anal. Calc.  $\text{C}_{18}\text{H}_{15}\text{O}_4$ : C, 68.78; H, 4.84. Found: C, 68.67; H, 4.70.

#### EXAMPLE 4

##### 3-(2-Benzoyloxy-3-methoxyphenyl)-7-methoxy-4-methyl-chromen-2-one



10. The title compound was prepared as a tan foamy solid according to the procedure described in Example 1 with substitution of 2-benzyloxy-4-methoxyphenylacetic acid for the 2,3-dimethoxyphenylacetic acid reagent.

MS (CI)  $m/z$  403 ( $\text{M}+\text{H}$ ) $^+$ , 425 ( $\text{M}+\text{Na}$ ) $^+$ , 827 ( $2\text{M}+\text{Na}$ ) $^+$

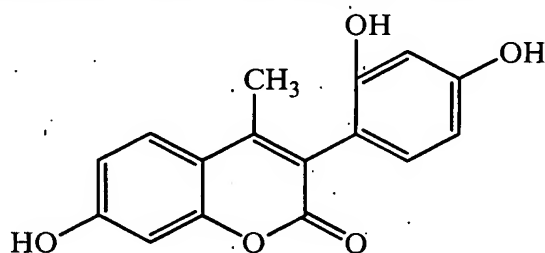
15  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.53 (1H, d,  $J$  = 9.4 Hz), 7.30 – 7.23 (5H, m), 7.11 (1H, d,  $J$  = 8.96 Hz), 6.88 – 6.85 (2H, m), 5.06 (2H, d,  $J$  = 2.00 Hz), 3.88 (3H, s), 3.81 (3H, s), 2.22 (3H, s)

IR (KBr): 1712, 1619, 1603, 1579, 1564, 1509  $\text{cm}^{-1}$

Anal. Calc  $\text{C}_{25}\text{H}_{22}\text{O}_5/0.1 \text{ H}_2\text{O}$ : C, 74.28; H, 5.54. Found: C, 74.10; H, 5.38.

20

25

**EXAMPLE 5****3-(2,4-Dihydroxyphenyl)-7-hydroxy-4-methyl-chromen-2-one**

A mixture of acetic acid 3-(2,4-dimethoxyphenyl)-7-hydroxy-4-methyl-2-oxo-2*H*-chromen-7-yl ester, prepared as in Example 1 (0.177g, 0.5 mmol, 1eq) and dry pyridine hydrochloride (0.9g, 8.8 mmol, 16 eq) was stirred and heated in an oil bath to a melt, at 210°C under a closed nitrogen atmosphere in a loosely stoppered round bottom flask for 1 hour. After cooling to room temperature the reaction mixture was triturated with water and the aqueous solution was extracted several times with ethyl acetate until the latter was colorless. Combined organic extracts were washed with brine, dried (anhydrous sodium sulphate), filtered and evaporated to yield the title compound as a pinkish crystalline solid.

mp 282-283°C

MS (CI)  $m/z$  285 ( $M+H$ )<sup>+</sup>, 306 ( $M+Na$ )<sup>+</sup>; loop negative 283 ( $M-H$ )

<sup>1</sup>H NMR (300 MHz, DMSO-*d*<sub>6</sub>): δ 10.47 (1H, brs), 9.34 (2H, s), 7.62 (1H, d, *J* = 8.8 Hz), 6.81 (2H, d,d, *J* = 2.5, 8.3 Hz), 6.72 (1H, d, *J* = 2.2 Hz), 6.35 (1H, d, *J* = 2.1 Hz), 6.27 (1H, d,d, *J* = 2.1, 8.2 Hz) 2.13 (3H, s)

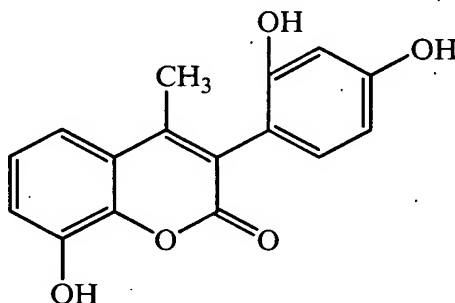
IR (KBr): 3454, 3264, 1673, 1616, 1562, 1509, 1461, 1379, 1350, 1282, 1157, 1106 cm<sup>-1</sup>

Anal. Calc. C<sub>16</sub>H<sub>12</sub>O<sub>5</sub>/0.25 H<sub>2</sub>O: C, 66.55; H, 4.36. Found: C, 66.63; H, 4.53.



**EXAMPLE 6**

**3-(2,3-Dihydroxyphenyl)-7-hydroxy-4-methyl-chromen-2-one**



The title compound was prepared according to the procedure described in Example 5 with substitution of acetic acid 3-(2,4-dimethoxyphenyl)-8-hydroxy-4-methyl-2-oxo-2*H*-chromen-7-yl ester, prepared in Example 2, for acetic acid 3-(2,4-dimethoxyphenyl)-7-hydroxy-4-methyl-2-oxo-2*H*-chromen-7-yl ester.

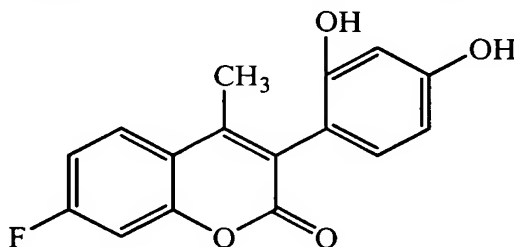
mp 273-274°C

MS (CI)  $m/z$  285 ( $M+H$ )<sup>+</sup>, 307 ( $M+Na$ )<sup>+</sup>, loop negative 283 ( $M-H$ )

<sup>1</sup>H NMR (300 MHz, DMSO-*d*<sub>6</sub>): δ 10.10 (1H, s), 9.32 (1H, s), 9.24 (1H, s), 7.23 – 7.07 (3H, m), 6.85 (1H, d,  $J$  = 8.23 Hz), 6.37 (1H, d,  $J$  = 2.27 Hz), 6.29 (1H, d,  $J$  = 2.30, 8.24 Hz), 2.17 (3H, s)

**EXAMPLE 7**

**3-(2,4-Dihydroxyphenyl)-7-fluoro-4-methyl-chromen-2-one**



The title compound was prepared according to the procedure outlined in Example 5 with substitution of 3-(2,4-dimethoxyphenyl)-7-fluoro-4-methyl-2-oxo-2*H*-chromen-7-yl ester, prepared in Example 3, for acetic acid 3-(2,4-dimethoxyphenyl)-7-hydroxy-4-methyl-2-oxo-2*H*-chromen-7-yl ester.

mp 266-268°C

MS (CI)  $m/z$  287 ( $M+H$ )<sup>+</sup>, 309 ( $M+Na$ )<sup>+</sup>; loop negative 285 ( $M-H$ )

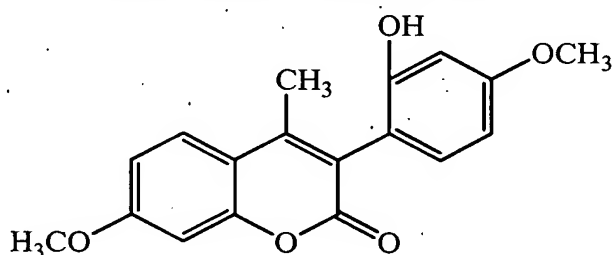
$^1\text{H}$  NMR (300 MHz, acetone- $d_6$ ):  $\delta$  8.36 (1H, s), 8.12 (1H, s), 7.91 – 7.85 (1H, m), 7.37 – 7.10 (2H, m), 6.98 (1H, d,  $J$  = 8.24 Hz), 6.50 (1H, d,  $J$  = 8.32 Hz), 6.46 (1H, d, d,  $J$  = 2.37, 8.24 Hz), 2.31 (3H, s)

IR (KBr): 3329, 3164, 1685, 1611, 1570, 1272, 1116  $\text{cm}^{-1}$

5      Anal. Calc.  $\text{C}_{18}\text{H}_{11}\text{FO}_4/0.1 \text{ H}_2\text{O}$ : C, 66.71; H, 3.92. Found: C, 66.63; H, 4.06.

### EXAMPLE 8

#### 3-(2-Hydroxy-4-methoxyphenyl)-7-methoxy-4-methyl-chromen-2-one



10

A solution of 3-(2-benzyloxy-3-methoxyphenyl)-7-methoxy-4-methyl-chromen-2-one (0.98 g, 2.44 mmol), prepared as in Example 4, in glacial acetic acid (8 mL) was treated with concentrated hydrochloric acid (3.5 mL) and the mixture stirred and heated to 60°C for about 20 hours. Reaction monitoring by  
15 mass spectrum and thin layer chromatography revealed the presence of the starting material, so additional acetic acid (4 mL) and hydrochloric acid (3 mL) were added and stirring and heating continued for another 20 hours. The reaction mixture was then evaporated to dryness in vacuum and the residue diluted with water. The precipitated crystalline pinkish, solid, crude title  
20 compound was isolated by filtration, washed with water and dried. The resulting product was triturated with ether, filtered and washed with additional ether to yield the title product as a solid.

mp 213–214°C

MS (CI)  $m/z$  313 ( $\text{M}+\text{H}^+$ ); ( $\text{M}-\text{H}$ , loop negative)

25

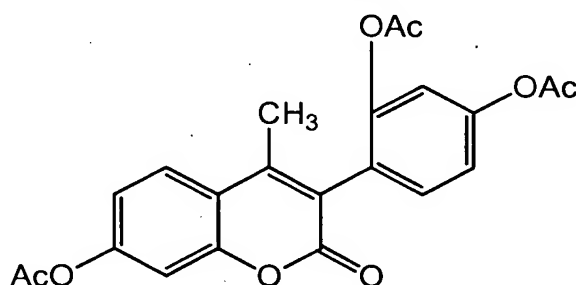
$^1\text{H}$  NMR (300 MHz, DMSO- $d_6$ ):  $\delta$  9.40 (1H, brs), 7.73 (1H, d,  $J$  = 8.68 Hz), 7.01 – 6.96 (3H, m), 6.47 (1H, s), 6.46 (1H, d,  $J$  = 6.60 Hz), 3.88 (3H, s), 3.74 (3H, s), 2.16 (3H, s)

IR (KBr): 3300, 1669, 1603, 1562  $\text{cm}^{-1}$ .

Anal. Calc.  $C_{18}H_{16}O_5$ : C, 69.22; H, 5.16. Found: C, 69.42; H, 5.18.

### EXAMPLE 9

#### Acetic acid 3-acetoxy-4-(7-acetoxy-4-methyl-2-oxo-2H-chromen-3-yl)-phenyl ester



A mixture of 3-(2,4-dihydroxyphenyl)-7-hydroxy-4-methyl-chromen-2-one (0.72g, 2.533 mmol), prepared as in Example 5, acetic anhydride (2 mL, about 20 mmol) and pyridine (0.2 mL, about 2.2 mmol) was heated to 70°C under nitrogen for 18 hours. The resulting mixture was cooled. To then mixture was then added water and the mixture stirred at room temperature for 30 minutes, then extracted with dichloromethane. The organic extracts were washed with brine, dried (anhydrous sodium sulphate), filtered and evaporated to a foam. The foam was crystallized by triturating the foam with ethyl acetate/ether to yield the title product as a beige, crystalline solid.

mp 145-145°C

MS (CI)  $m/z$  411 ( $M+H$ )<sup>+</sup>, 432 ( $M+Na$ )<sup>+</sup>

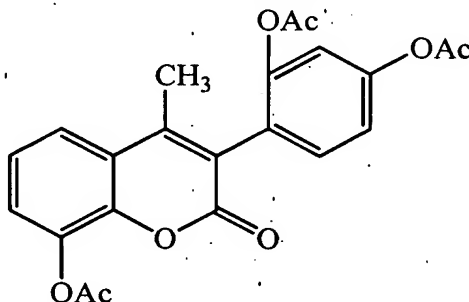
<sup>1</sup>H NMR (300 MHz,  $CDCl_3$ ):  $\delta$  7.70 (1H, d,  $J$  = 8.7 Hz), 7.26 (1H, d,  $J$  = 2.3 Hz), 7.16-7.10 (4H, m), 2.37 (3H, s), 2.32 (3H, s), 2.28 (3H, s), 2.11 (3H, s)

IR (KBr): 1763, 1726, 1611, 1573, 1501, 1428, 1373, 1202  $cm^{-1}$

Anal. Calc.  $C_{22}H_{18}O_8$ : C, 64.39; H, 4.42. Found: C, 64.16; H, 4.23.

**EXAMPLE 10**

**Acetic acid 5-acetoxy-2-(8-acetoxy-4-methyl-2-oxo-2H-chromen-3-yl)-phenyl ester**



5. The title compound was prepared according to the procedure described in Example 9 with substitution of 3-(2,3-dihydroxyphenyl)-7-hydroxy-4-methyl-chromen-2-one, prepared as in Example 6, for 3-(2,4-dihydroxyphenyl)-7-hydroxy-4-methyl-chromen-2-one.

mp 119-120°C

- 10 MS m/z 369 [(M- Ac)+H]<sup>+</sup> 411(M+H)<sup>+</sup>, 433 (M+Na)<sup>+</sup>

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.59 – 7.54 (1H, m), 7.34 – 7.29 (2H, m), 7.25 (1H, d, J = 8.41 Hz), 2.43 (3H, s), 2.32 (3H, s), 2.29 (3H, s), 2.11 (3H, s)

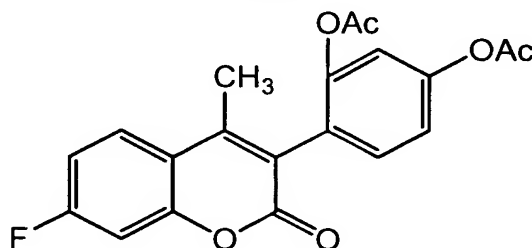
IR (KBr): 1769, 1720, 1610, 1578, 1501, 1462, 1371, 1202 cm<sup>-1</sup>

Anal. Calc. C<sub>18</sub>H<sub>11</sub>FO<sub>4</sub>/0.1 H<sub>2</sub>O: C, 66.71; H, 3.92. Found: C, 66.63; H,

- 15 4.06.

**EXAMPLE 11**

**Acetic acid 5-acetoxy-2-(7-fluoro-4-methyl-2-oxo-2H-chromen-3-yl)-phenyl ester**



- 20

The title compound was prepared according to the procedure described in Example 9 with substitution of 3-(2,4-dihydroxyphenyl)-7-fluoro-4-methyl-

chromen-2-one, prepared as in Example 7, for 3-(2,4-dihydroxyphenyl)-7-hydroxy-4-methyl-chromen-2-one.

mp 148-149°C

MS (CI) m/z 329 [(M- Ac)+H]<sup>+</sup>, 371(M+H)<sup>+</sup>, 393 (M+Na)<sup>+</sup>

5 <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.70 – 7.65 (1H, m), 7.27 (2H, d, J = 8.06 Hz), 7.14 – 7.05 (3H, m), 2.32 (3H, s), 2.28 (3H, s), 2.109 (3H, s)

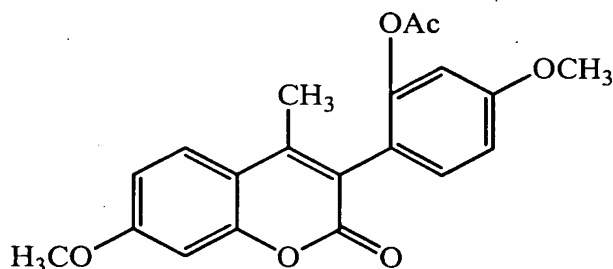
IR (KBr): 1765, 1726, 1706, 1612, 1529, 1500, 1429, 1372, 1273, 1191 cm<sup>-1</sup>

Anal. Calc. C<sub>20</sub>H<sub>15</sub>FO<sub>6</sub>: C, 64.87; H, 4.08. Found: C, 64.69; H, 3.94.

10

### EXAMPLE 12

#### Acetic acid 3-methoxy-2-(7-methoxy-4-methyl-2-oxo-2H-chromen-3-yl)-phenyl ester



15 The title compound was prepared as a light pink solid according to the procedure described in Example 9 with substitution of 3-(2-hydroxy-4-methoxyphenyl)-7-hydroxy-4-methyl-chromen-2-one, prepared as in Example 8, for 3-(2,4-dihydroxyphenyl)-7-hydroxy-4-methyl-chromen-2-one.

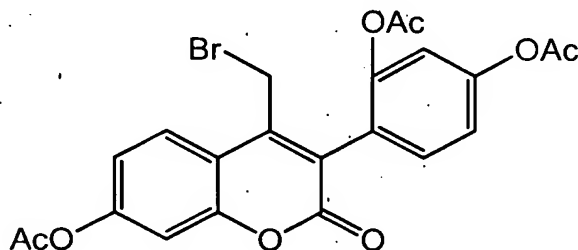
mp 125–126°C

20 MS (CI) m/z 355 (M+H)<sup>+</sup>

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.57 (1H, d, J = 8.76 Hz), 7.17 (1H, d, J = 8.54 Hz), 6.91 – 6.86 (3H, m), 6.78 (1H, d, J = 2.52 Hz), 3.89 (3H, s), 3.84 (3H, s), 2.24 (3H, s), 2.09 (3H, s)

IR (KBr): 1765, 1716, 1618, 1605, 1564, 1508, 1206 cm<sup>-1</sup>

25 Anal. Calc. C<sub>20</sub>H<sub>18</sub>O<sub>6</sub>; C, 67.79; H, 5.12. Found: C, 67.94, H, 5.14.

**EXAMPLE 13****Acetic acid 3-acetoxy-4-(7-acetoxy-4-bromomethyl-2-oxo-2H-chromen-3-yl)-phenyl ester**

5 A mixture of acetic acid 3-acetoxy-4-(7-acetoxy-4-methyl-2-oxo-2H-chromen-3-yl)-phenyl ester (0.767g, 1.87 mmol, 1 eq), N-bromosuccinimide (0.349 g, 1.962 mmol, 1.05 eq) and benzoyl peroxide (0.035g, 0.145 mmol) in carbon tetrachloride (30 mL) was stirred and heated to reflux under nitrogen in presence of a 100W tungsten lamp for 20 hours. Reaction monitoring by MS  
10 and TLC showed the presence unreacted starting material, and additional N-bromosuccinimide (0.060 g, 0.34 mmol) and benzoyl peroxide (0.008g) were added to the reaction mixture and the reaction was heated at reflux under nitrogen for an additional 2 hours. The mixture was evaporated to dryness,  
15 dissolved in hot dichloromethane and purified by column chromatography on silica gel using 3% ethyl acetate/ hexane as an eluent to yield the title product as a tan crystalline solid.

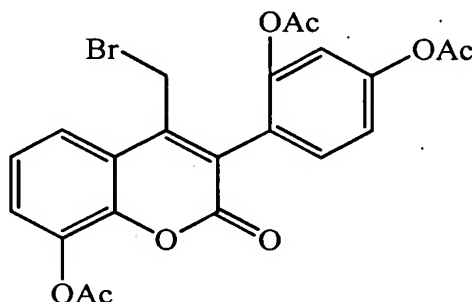
mp 171- 172°C

MS (cl) m/z 488 (M+H)<sup>+</sup>, 512 (M+Na)<sup>+</sup>

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.81 (1H, d, J = 8.7 Hz), 7.49 (1H, d, J =  
20 8.3 Hz), 7.19 – 7.13 (4H, m), 4.40 (1H, d, J = 10.6 Hz), 4.27 (1H, d, J = 10.7 Hz), 2.38 (3H, s), 2.33 (3H, s), 2.11 (3H, s)

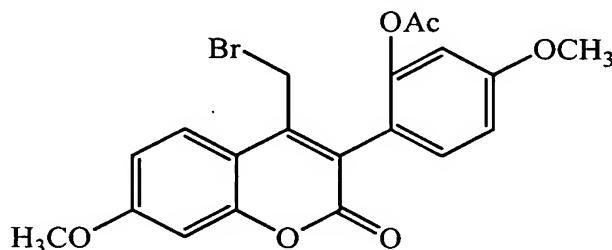
IR (KBr): 1766, 1725, 1613, 1571, 1499, 1426, 1369, 1194 cm<sup>-1</sup>

Anal. Calc. C<sub>22</sub>H<sub>17</sub>BrO<sub>8</sub>: C, 54.01; H, 3.50. Found: C, 54.03; H, 3.42.

**EXAMPLE 14****Acetic acid 5-acetoxy-2-(8-acetoxy-4-bromomethyl-2-oxo-2H-chromen-3-yl)-phenyl ester**

5 The title compound was prepared as a crystalline solid according the procedure described in Example 13 with substitution of acetic acid 5-acetoxy-2-(8-acetoxy-4-methyl-2-oxo-2H-chromen-3-yl)-phenyl ester, prepared as in Example 10, for acetic acid 3-acetoxy-4-(7-acetoxy-4-methyl-2-oxo-2H-chromen-3-yl)-phenyl ester.

10

**EXAMPLE 15****Acetic acid 2-(4-bromomethyl-7-methoxy-2-oxo-2H-chromen-3-yl)-5-methoxy-phenyl ester**

15 The title compound was prepared as a crystalline solid according the procedure described in Example 13 with substitution of acetic acid 3-methoxy-2-(7-methoxy-4-methyl-2-oxo-2H-chromen-3-yl)-phenyl ester, prepared a in Example 15, for acetic acid 3-acetoxy-4-(7-acetoxy-4-methyl-2-oxo-2H-chromen-3-yl)-phenyl ester.

20

mp 132 – 133°C

MS (CI)  $m/z$  435 (M+H)<sup>+</sup>, 391 [(M-Ac)+H]<sup>+</sup>

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.68 (1H, d, J = 8.80 Hz), 7.40 (1H, d, J = 8.58 Hz), 6.97 – 6.91 (3H, m), 6.88 (1H, d, J = 2.28 Hz), 6.80 (1H, d, J = 2.40

Hz), 4.39 (1H, d, J = 10.39 Hz), 4.27 (1H, d, J = 10.38 Hz), 3.90 (3H, s), 3.86 (3H, s), 2.09 (3H, s)

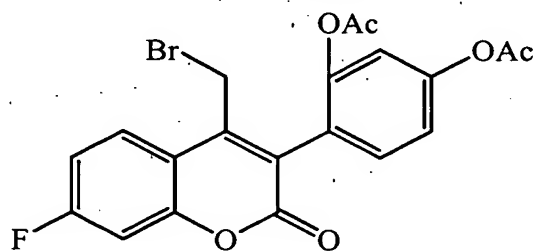
IR (KBr): 1785, 1721, 1605, 1564, 1512, 1453, 1289, 1213, 1105  $\text{cm}^{-1}$

Anal. Calc.  $\text{C}_{20}\text{H}_{17}\text{BrO}_6$ : C, 55.44; H, 3.96. Found: C, 55.45; H, 4.02.

5

### EXAMPLE 16

#### Acetic acid 3-acetoxy-4-(4-bromomethyl-7-fluoro-2-oxo-2H-chromen-3-yl)-phenyl ester



10 The title compound was prepared as a crystalline solid according to the procedure described in Example 13 with substitution of acetic acid 5-acetoxy-2-(7-fluoro-4-methyl-2-oxo-2H-chromen-3-yl)-phenyl ester, prepared as in Example 11, for acetic acid 3-acetoxy-4-(7-acetoxy-4-methyl-2-oxo-2H-chromen-3-yl)-phenyl ester.

15 mp 230–231°C

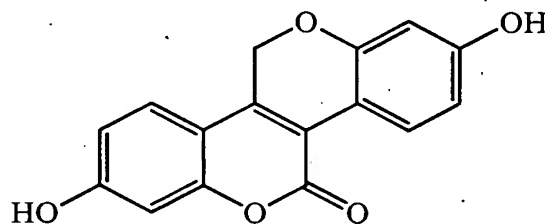
MS (CI)  $m/z$  451 ( $\text{M}+\text{H}^+$ ), 471 ( $\text{M}+\text{Na}^+$ ), 409 [ $(\text{M}-\text{Ac})+\text{H}^+$ ]

$^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.80 (1H, d, d, J = 3.37, 9.62 Hz), 7.49 (1H, d, J = 8.35 Hz), 7.21 – 7.11 (4H, m), 4.39 (1H, d, J = 10.61 Hz), 4.27 (1H, d, J = 10.68), 2.33 (3H, s), 2.10 (3H, s)

20 IR (KBr): 1758, 1727, 1617, 1581, 1371, 1215  $\text{cm}^{-1}$ .

25



**EXAMPLE 17****2, 8-Dihydroxy-11H-chromeno[4,3-c]chromen-5-one Compound #1****Method A:**

5 To a stirred solution of 3-(2-hydroxy-4-methoxyphenyl)-7-hydroxy-4-methyl-chromen-2-one (0.100g, 0.204 mmol), prepared as in Example 13, in a mixture of methanol (5 mL) and acetone (2 mL) was added at room temperature anhydrous potassium carbonate (0.08474 g, 0.6 mmol). The solution immediately turned yellow. The solution was stirred for 2 hours,  
 10 evaporated to dryness, the residue was dissolved in water (15 mL) and then acidified with dilute hydrochloric acid to about pH 1. The precipitated yellow solid was isolated by filtration, washed with water and dried to yield the title compound.

mp >350°C

15 MS (CI)  $m/z$  283 ( $M+H$ )<sup>+</sup>, 305 ( $M+Na$ )<sup>+</sup>, 321 ( $M+K$ )<sup>+</sup>; loop negative 281 ( $M-H$ )

<sup>1</sup>H NMR (300 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  10.65 (1H, brs), 9.85 (1H, brs), 8.19 (1H, d,  $J = 8.0$  Hz), 7.62 (1H, d,  $J = 8.1$  Hz), 6.82 (1H, d,  $J = 8.2$  Hz), 6.76 (1H, s), 6.47 (1H, d,  $J = 7.75$  Hz), 6.38 (1H, s), 5.33 (2H, s)

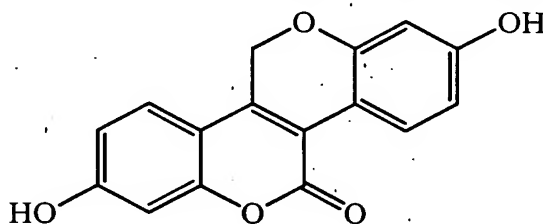
20 IR (KBr): 3373, 1699, 1620, 1597, 1508, 1464, 1299, 1264, 1166  $cm^{-1}$

Anal. Calc. C<sub>16</sub>H<sub>10</sub>O<sub>5</sub>/0.2 H<sub>2</sub>O: C, 67.23; H, 3.67. Found: C, 67.31; H, 3.55.

25

**EXAMPLE 18**

**2, 8-Dihydroxy-11H-chromeno[4,3-c]chromen-5-one Compound #1**



**Method B:**

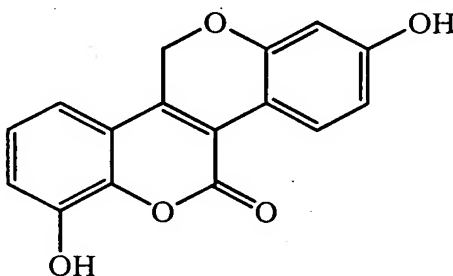
- 5           The title product was prepared according to the procedure described in Example 5 with substitution of 2,8-dimethoxy-11H-chromeno[4,3c]chromen-5-one, prepared as in Example 21, for acetic acid 3-(2,4-dimethoxyphenyl)-7-hydroxy-4-methyl-2-oxo-2H-chromen-7-yl ester.

m.p. >360°C

10

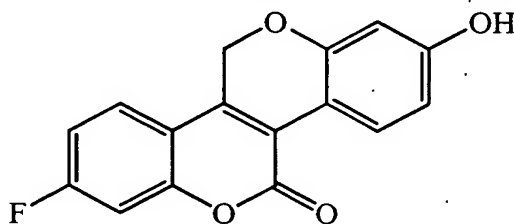
**EXAMPLE 19**

**2, 7-Dihydroxy-11H-chromeno[4,3-c]chromen-5-one Compound #84**



- 15           The title compound was prepared according the procedure described in Example 17 with substitution of acetic acid 5-acetoxy-2-(8-acetoxy-4-bromomethyl-2-oxo-2H-chromen-3-yl)-phenyl ester, prepared as in Example 10, for 3-(2-hydroxy-4-methoxyphenyl)-7-hydroxy-4-methyl-chromen-2-one.

20

**EXAMPLE 20****8-Fluoro-2-hydroxy-11H-chromeno[4,3-c]chromen-5-one Compound #37**

The title compound was prepared as a yellow solid according the  
 5 procedure described in Example 17 with substitution of acetic acid 3-acetoxy-4-  
 (4-bromomethyl-7-fluoro-2-oxo-2H-chromen-3-yl)-phenyl ester, prepared as in  
 Example 16, for 3-(2-hydroxy-4-methoxyphenyl)-7-hydroxy-4-methyl-chromen-  
 2-one.

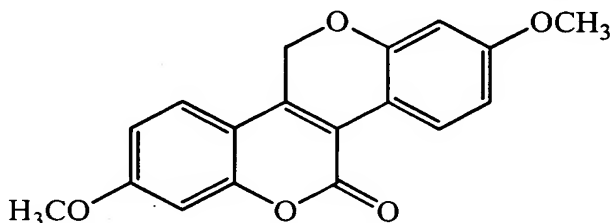
mp 259–260°C

10 MS (CI)  $m/z$  285 ( $M+H$ )<sup>+</sup>, 307 ( $M+Na$ )<sup>+</sup>; loop negative 281 ( $M-H$ )

<sup>1</sup>H NMR (300 MHz, DMSO-d<sub>6</sub>):  $\delta$  9.99 (1H, s), 8.22 (1H, d,  $J$  = 8.70 Hz),  
 7.87 (1H, d, d,  $J$  = 6.12, 8.90 Hz), 7.46 (1H, d, d,  $J$  = 2.52, 9.53 Hz), 7.31 (1H,  
 d, t,  $J$  = 2.56, 8.77 Hz), 6.51 (1H, d, d,  $J$  = 2.45, 8.71 Hz), 6.41 (1H, d,  $J$  = 2.41  
 Hz), 5.40 (2H, s)

15 IR (KBr): 3341, 1697, 1621 1506, 1455, 1275, 1110 cm<sup>-1</sup>

Anal. Calc. C<sub>16</sub>H<sub>9</sub>F<sub>2</sub>O<sub>4</sub>: C, 67.61; H, 3.19. Found: C, 65.252; H, 3.38.

**EXAMPLE 21****2, 8-DiMethoxy-11H-chromeno[4,3-c]chromen-5-one Compound #2**

20 The title compound was prepared as a light yellow solid according the  
 procedure described in Example 17 with substitution of acetic acid 2-(4-  
 bromomethyl-7-methoxy-2-oxo-2H-chromen-3-yl)-5-methoxy-phenyl ester,  
 prepared as in Example 15, for 3-(2-hydroxy-4-methoxyphenyl)-7-hydroxy-4-  
 25 methyl-chromen-2-one.

mp 200–201°C

MS (CI)  $m/z$  311 (M+H)<sup>+</sup>, 333 (M+ Na)<sup>+</sup>

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 8.49 (1H, d, J = 8.83 Hz); 7.37 (1H, d, J = 8.46 Hz), 6.90 (1H, d, d, J = 2.67, 8.84 Hz), 6.53 (1H, d, J = 2.36 Hz), 5.27 (2H, s), 3.89 (3H, s), 3.83 (3H, s)

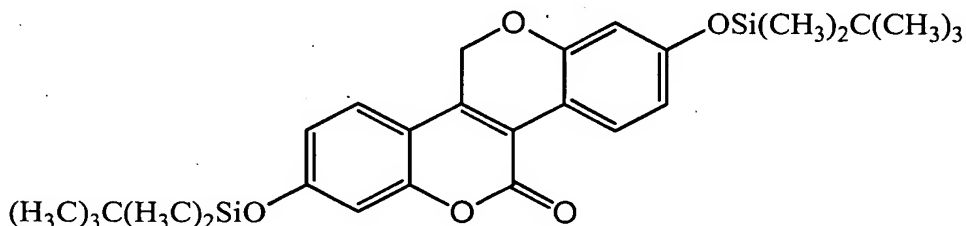
IR (KBr): 1712, 1621 1573, 1504, 1168 cm<sup>-1</sup>

Anal. Calc. for C<sub>18</sub>H<sub>14</sub>O<sub>5</sub>: C, 69.67; H, 4.55. Found: C, 69.42; H, 4.54.

### EXAMPLE 22

#### 10 2, 8-Bis-(*tert*-butyl-dimethyl-silyloxy)-11*H*-chromeno[4,3-*c*]chromen-5-one

##### Compound #3



A slurry of 2, 8-dihydroxy-11*H*-chromeno[4,3-*c*]chromen-5-one (0.322 g, 1.1412 mmol, 1 eq), prepared as in Example 17, in dichloromethane (10 mL) was treated with triethylamine (0.8 mL, 5.70 mmol, 5 eq), followed by the addition of *t*-butyldimethylsilyl chloride (0.585 g, 3.88 mmol, 3.4 eq). The reaction mixture was stirred at room temperature under nitrogen for 18 hours. (The slurry was observed to become a clear solution after about 30 minutes of stirring.) The reaction mixture was diluted with hexane (~35 mL) and washed once with brine. The aqueous washing was re-extracted with hexane. The combined organic extracts were dried (anhydrous sodium sulphate), filtered and evaporated in vacuum to yield a yellow solid residue. The solid residue was recrystallized from hexane to yield the title compound as a light yellow crystalline solid.

25 mp 150-151°C

MS (CI)  $m/z$  533 (M+Na)<sup>+</sup>

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 8.43 (1H, d, J = 8.6 Hz), 7.33 (1H, d, J = 8.3 Hz), 6.84 (1H, s), 6.83 (1H, d, J = 9.1 Hz), 6.57 (1H, d, d, J = 2.4, 8.7 Hz),

6.47 (1H, d, J = 2.22 Hz), 5.26 (2H, s), 1.00 (9H, s), 0.99 (9H, s), 0.26 (3H, s), 0.23 (6H, s)

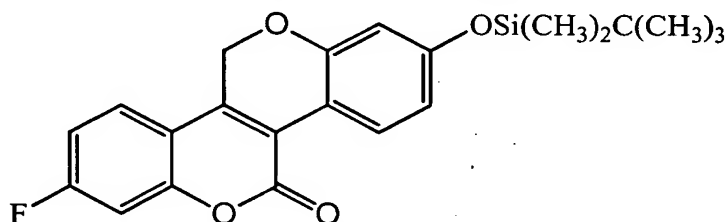
IR (KBr): 2957, 2927, 2883, 2855, 1713, 1618, 1567, 1498, 1287  $\text{cm}^{-1}$

Anal. Calc. for  $\text{C}_{24}\text{H}_{38}\text{O}_5\text{Si}_2$ : C, 65.84; H, 7.50. Found: C, 65.53; H, 7.43.

5

### EXAMPLE 23

#### 2-(tert-Butyl-dimethyl-silyloxy)-8-fluoro-11H-chromeno[4,3-c]chromen-5-one Compound #85



10 The title product was prepared as a colorless crystalline solid according to the procedure described in Example 22 with substitution of 8-fluoro-2-hydroxy-11H-chromeno[4,3-c]chromen-5-one, prepared as in Example 20, for 2, 8-dihydroxy-11H-chromeno[4,3-c]chromen-5-one.

mp 197–198°C

15 MS (CI)  $m/z$  399 ( $\text{M}+\text{H}$ )<sup>+</sup>, 421 ( $\text{M}+\text{Na}$ )<sup>+</sup>, 819 ( $2\text{M}+\text{Na}$ )<sup>+</sup>

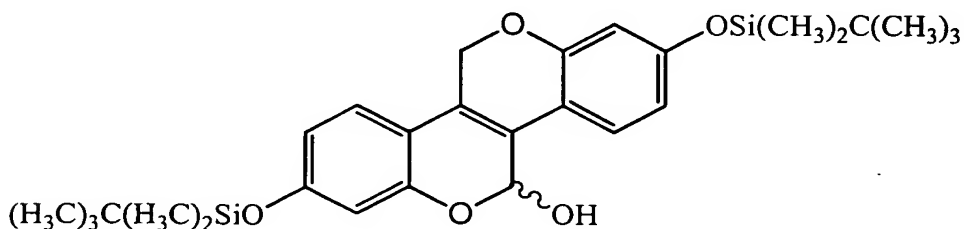
<sup>1</sup>H NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  8.42 (1H, d, J = 8.83 Hz), 7.45 (1H, d, d, J = 5.79, 8.46 Hz), 7.13 – 7.04 (2H, m), 6.58 (1H, d, d, J = 2.48, 8.71 Hz), 6.48 (1H, d, J = 2.45 Hz), 5.27 (2H, s), 0.99 (9H, s), 0.24 (6H, s)

IR (KBr): 1724, 1619 1503, 1302, 1262, 1173, 832  $\text{cm}^{-1}$

20 Anal. Calc.  $\text{C}_{22}\text{H}_{23}\text{FO}_4\text{Si}$ : C, 66.31; H, 5.82. Found: C, 66.05; H, 5.80.

### EXAMPLE 24

#### 2, 8-Bis-(tert-Butyl-dimethyl-silanlyoxy)-5,11-dihydro-chromeno [4,3-c]-chromen-5-ol Compound #4



25

A solution of 2, 8-bis-(*tert*-butyl-dimethyl-silyloxy)-11*H*-chromeno[4,3-  
c]chromen-5-one (5.016 g, 9.82 mmol, 1eq) in toluene (525 mL) was cooled to -  
78°C in a 1L 3-neck round bottom flask equipped with a mechanical stirrer, a  
nitrogen inlet and a dropping funnel. To the reaction mixture was slowly added  
5 a toluene solution of diisobutylaluminum hydride (19 mL of 1.5 M, 28.48 mmol,  
2.9 eq), with the temperature of the reaction mixture maintained at less than -  
70° C. The reaction was stirred for 5 hours, quenched with addition of  
methanol (25 mL) followed by 10% citric acid solution (~140 mL). The resulting  
solution was diluted with dichloromethane (525 mL), the solution washed with a  
10 saturated solution of Rochelle salt (250 mL), then washed with brine, dried on  
anhydrous sodium sulphate, filtered and evaporated to yield the crude  
compound as a yellow solid. The solid was recrystallized from a  
dichloromethane:hexane mixture (1:1) to yield the title product as an ivory,  
crystalline solid.

15 mp 188-190°C

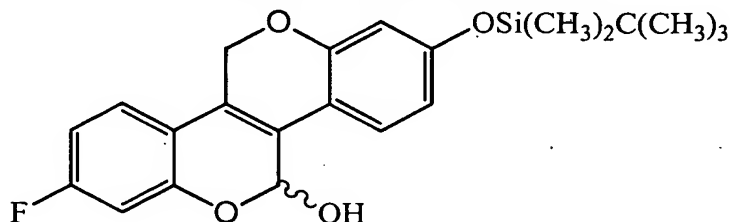
MS (CI)  $m/z$  511 ( $M+H$ )<sup>+</sup>, 533 ( $M+Na$ )<sup>+</sup>, 495 [ $(M-H_2O)+H$ ]<sup>+</sup>, 1043  
( $2M+Na$ )<sup>+</sup>

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.15 (1H, d,  $J$  = 8.4 Hz), 6.96 (1H,  $J$  = 8.4  
Hz), 6.59 (1H, d,  $J$  = 2.24 Hz), 6.54 (1H, d, d,  $J$  = 2.31, 11.62 Hz), 6.46 (1H, d,  
20 d,  $J$  = 2.31, 8.35 Hz), 6.41 (1H, d,  $J$  = 2.31 Hz), 6.11 (1H, d,  $J$  = 8.1 Hz,  
collapsed to a s upon D<sub>2</sub>O exchange), 3.01 (1H, d,  $J$  = 8.2 Hz, D<sub>2</sub>O  
exchangeable), 0.98 (18H, s), 0.22 (6H, s), 0.21 (6H, s)

IR (KBr): 3407, 2950, 2928, 2857, 1612, 1572, 1496, 1276, 1252, 1166,  
1126, 1020, 838, 777 cm<sup>-1</sup>.

25

30

**EXAMPLE 25****2-(*tert*-Butyl-dimethyl-silanlyoxy)-8-fluoro-5,11-dihydro-chromeno [4,3-c]-chromen-5-ol Compound #86**

5 The title product was prepared as a colorless crystalline solid according to the procedure described in Example 24 with substitution of 2-(*tert*-Butyl-dimethyl-silyloxy)-8-fluoro-11*H*-chromeno[4,3-c]chromen-5-one, prepared as in Example 20, for 2, 8-Dihydroxy-11*H*-chromeno[4,3-c]chromen-5-one.

mp 166–167°C

10 MS (CI)  $m/z$  401 ( $M+H$ )<sup>+</sup>, 423 ( $M+Na$ )<sup>+</sup>, 383 [( $M-H_2O$ )+ $H$ ]<sup>+</sup>

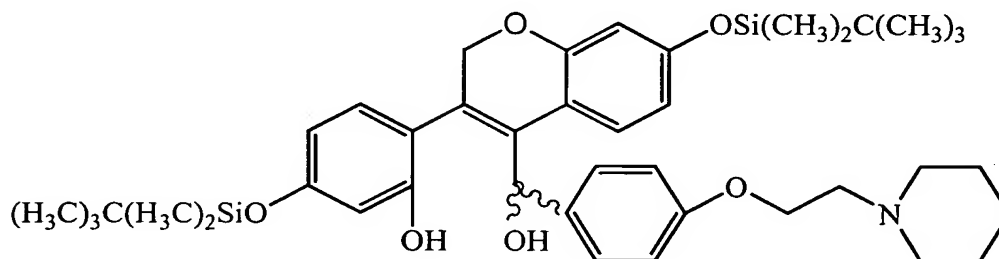
<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 8.42 (1H, d,  $J$  = 8.83 Hz), 7.45 (1H, d, d,  $J$  = 5.79, 8.46 Hz), 7.13 – 7.04 (2H, m), 6.58 (1H, d, d,  $J$  = 2.48, 8.71 Hz), 6.48 (1H, d,  $J$  = 2.45 Hz), 5.27 (2H, s), 0.99 (9H, s), 0.24 (6H, s)

IR (KBr): 3441, 1616, 1590 1566, 1504, 1294, 1283, 1142, 1028 cm<sup>-1</sup>.

15 Anal. Calc. C<sub>22</sub>H<sub>23</sub>FO<sub>4</sub>Si / 0.4 H<sub>2</sub>O: C, 64.81; H, 6.38. Found: C, 64.71; H, 6.19.

**EXAMPLE 26**

20 **5-(*tert*-Butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-hydroxy-[4-(2-piperidine-1-yl-ethoxy)-phenyl]-methyl}-2*H*-chromen-3-yl)-phenol**



In a single neck, 50 mL round bottom flask was dissolved and stirred 4-[2-(piperidin-1-yl)-ethoxy]-iodobenzene (0.828 g, 2.5 mmol, 3 eq), in

tetrahydrofuran (10 mL) under argon, and the mixture cooled to  $-22^{\circ}\text{C}$ . After 5 minutes of stirring, an ether solution of isopropylmagnesium bromide (1.244 mL of 2.13 M, 2.65 mmol, 3 eq) was added via syringe. The reaction mixture was then stirred for 2 hours at about  $-22^{\circ}\text{C}$ . A tetrahydrofuran solution of 2, 8-bis-  
 5 (tert-Butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno [4,3-c]-chromen-5-ol (0.512 g, 1 mmol, 1 eq, in 10 mL), prepared as in Example 24, was then added, the cooling bath was removed and the reaction mixture was allowed to warm to room temperature overnight. After about 18 hours, the reaction was worked-up  
 10 with addition of saturated ammonium acetate solution (15 mL) and extraction with ethyl ether (2 x 25 mL). The combined organic extracts were washed with brine and water, dried with anhydrous sodium sulphate, filtered and evaporated to yield a sticky semisolid residue. The title product was isolated as a viscous, colorless, semisolid foam via chromatography on silica gel eluted with 3% methanol/dichloromethane.

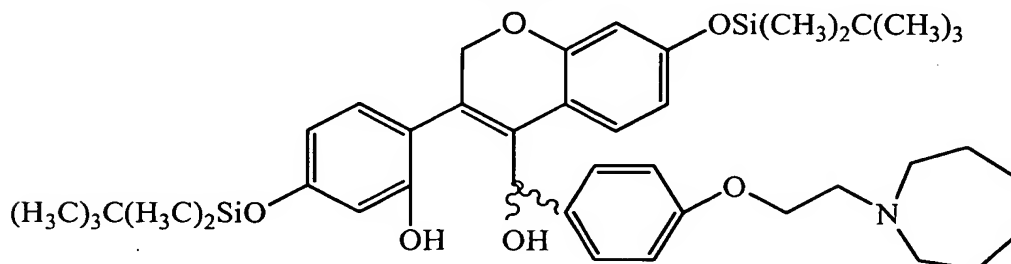
15 MS (CI)  $m/z$  718 ( $\text{M}+\text{H}^+$ ), loop negative 716 ( $\text{M}-\text{H}$ )

$^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.06 (4H, m), 6.62 (2H, d,  $J = 8.4$  Hz), 6.45–6.34 (3H, m), 5.38 (1H, brs.), 4.81 (2H, brs), 4.05 (2H, t), 2.80 (2H, t), 2.57 (4H, brs), 1.47 (4H, m), 1.46 (2H, m), 0.96 (9H, s), 0.93 (9H, s), 0.19 (6H, s), 0.14 (6H, s).

20

### EXAMPLE 27

2-[4-{[4-(2-Azepan-1-yl-ethoxy)-phenyl]hydroxymethyl}-7- (tert-Butyl-dimethyl-silyloxy)-2H-chromen-3-yl]-5-(tert-butyl-dimethyl-silyloxy)-phenol



25

The title product was prepared according to the procedure described in Example 26 with substitution of 4-[ 2-(azapan-1-yl)-ethoxy]-phenyl magnesium



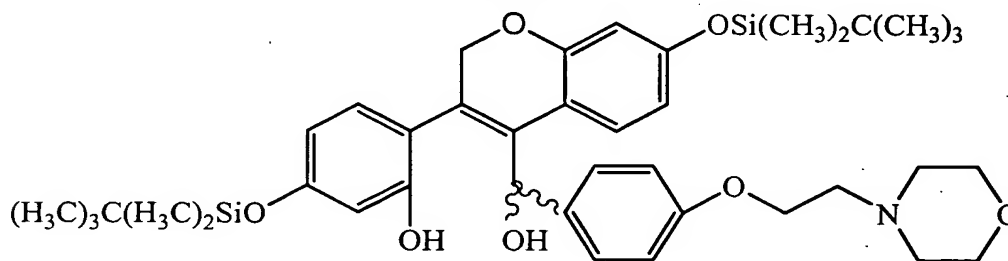
bromide (generated in situ from 4-[2-(azapan-1-yl)-ethoxy]-iodobenzene and isopropyl magnesium bromide) as the Grignard reagent, for the Grignard reagent 4-[2-(piperidin-1-yl)-ethoxy]-phenyl magnesium bromide.

MS (CI)  $m/z$  732 ( $M+H$ )<sup>+</sup>, loop negative 730 ( $M-H$ )

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>):  $\delta$  7.09–7.03 (4H, m), 6.66 (2H, d,  $J$  = 8.32 Hz), 6.45 – 6.28 (4H, m), 5.60 (1H, brs), 4.81 (2H, brs), 4.03 (2H, t), 2.97 (2H, m), 2.83 (4H, m), 1.61 – 1.53 (8H, m), 0.96 (9H, s), 0.93 (9H, s), 0.19 (6H, s), 0.15 (6H).

### EXAMPLE 28

5-(*tert*-Butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{hydroxy-[4-(2-morpholin-1-yl-ethoxy)-phenyl]-methyl}-2H-chromen-3-yl)-phenol



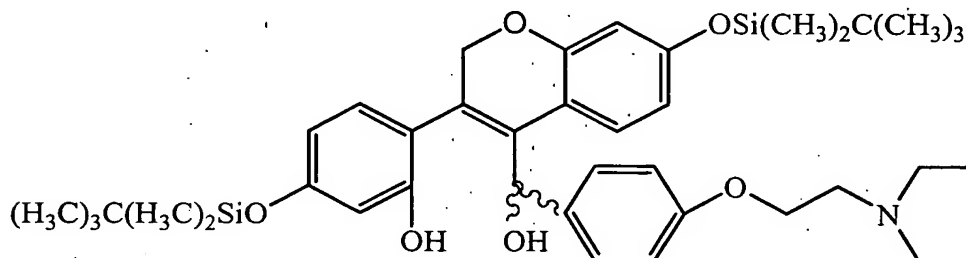
The title compound was prepared according to the procedure described in Example 26 with substitution of 4-[2-(morpholin-1-yl)-ethoxyphenyl] - magnesium bromide (generated in situ from 4-[2-(morpholin-1-yl)-ethoxy]-iodobenzene and isopropyl magnesium bromide) as the Grignard reagent, for the Grignard reagent 4-[2-(piperidin-1-yl)-ethoxyphenyl]- magnesium bromide.

MS (CI)  $m/z$  720 ( $M+H$ )<sup>+</sup>, 742 ( $M+Na$ )<sup>+</sup>; loop negative 718 ( $M-H$ )

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>):  $\delta$  7.06–7.02 (4H, m), 6.77 (2H, d,  $J$  = 7.98 Hz), 6.43 – 6.18 (4H, m), 5.67 (1H, brs), 4.81 (2H, brs), 4.05 (2H, t), 3.72 (4H, m), 2.77 (2H, t), 2.56 (4H, m), 0.96 (9H, s), 0.93 (9H, s), 0.19 (6H, s), 0.15 (6H,s).

**EXAMPLE 29**

**5-(*tert*-Butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-(hydroxy-[4-(2-pyrrolidin-1-yl-ethoxy)-phenyl]-methyl)-2*H*-chromen-3-yl)-phenol**



5

The title product was prepared according to the procedure described in Example 26 with substitution of 4-[2-(pyrrolidin-1-yl)-ethoxy]-phenyl magnesium bromide (generated in situ from 4-[2-(pyrrolidin-1-yl)-ethoxy]-iodobenzene and isopropyl magnesium bromide) as the Grignard reagent, for the Grignard reagent 4-[2-(piperidin-1-yl)-ethoxy]-phenyl magnesium bromide.

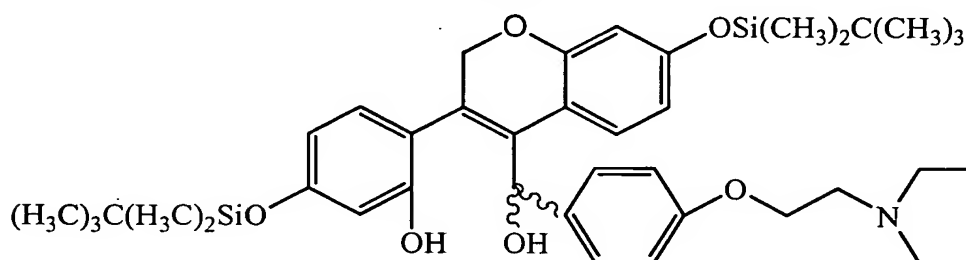
MS (CI)  $m/z$  704 ( $M+H$ )<sup>+</sup>, 726 ( $M+Na$ )<sup>+</sup>, loop negative 702 ( $M-H$ )

10

**EXAMPLE 30**

**5-(*tert*-Butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-(hydroxy-[4-(2-diethylamino-ethoxy)-phenyl]-methyl)-2*H*-chromen-3-yl)-phenol**

15



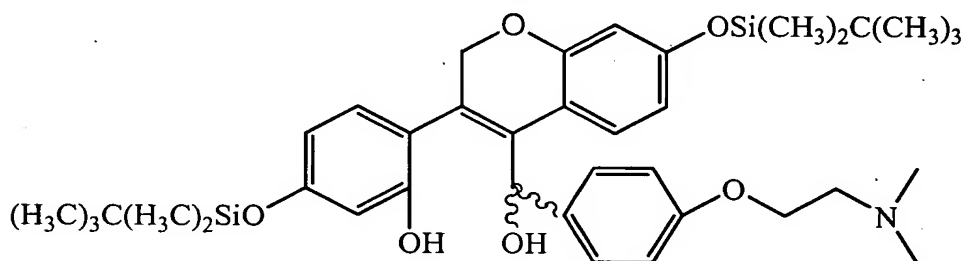
20

The title product was prepared according to the procedure described in Example 26 with substitution of 4-(2-diethylaminoethoxy)-phenyl magnesium bromide (generated in situ from 4-(2-diethylaminoethoxy)-iodobenzene and isopropyl magnesium bromide) as the Grignard reagent, for the Grignard reagent 4-[2-(piperidin-1-yl)-ethoxyphenyl]-magnesium bromide.

MS (CI)  $m/z$  706 ( $M+H$ )<sup>+</sup>, 728 ( $M+Na$ )<sup>+</sup>, loop negative 704 ( $M-H$ )

**EXAMPLE 31**

**5-(*tert*-Butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{hydroxy-[4-(2-dimethylamino-ethoxy)-phenyl]-methyl}-2*H*-chromen-3-yl)-phenol**



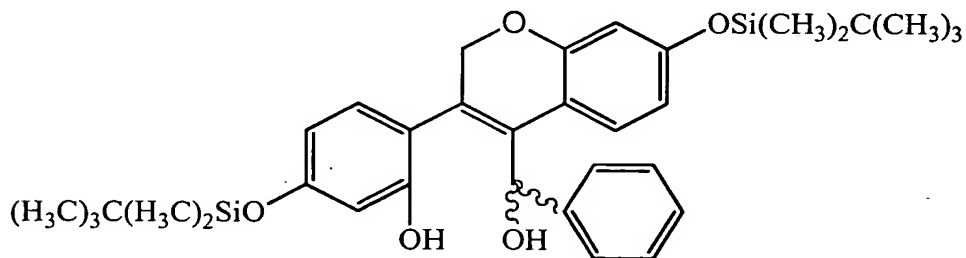
The title product was prepared according to the procedure described in Example 26 with substitution of 4-(2-diethylaminoethoxy)-phenyl magnesium bromide (generated in situ from 4-(2-diethylaminoethoxy)-iodobenzene and isopropyl magnesium bromide) as the Grignard reagent, for the Grignard reagent 4-[2-(piperidin-1-yl)-ethoxy]-phenyl magnesium bromide.

MS (CI)  $m/z$  678 ( $M+H$ )<sup>+</sup>, 700 ( $M+Na$ )<sup>+</sup>; loop negative 706 ( $M-H$ )

<sup>1</sup>HNMR (300 MHz, CDCl<sub>3</sub>)  $\delta$  7.09 (4H, m), 6.94 (2H, d,  $J$  = 8.10 Hz), 6.58–6.33 4H, m), 5.50 (1H, brs.), 4.82 (2H, brs), 4.00 (2H, t), 2.78 (2H, m), 2.38 (6H, s), 0.98 (9H, s), 0.94 (9H, s), 0.20 (6H, s), 0.15 (6H, s).

**EXAMPLE 32**

**5-(*tert*-Butyl-dimethyl-silyloxy)-2-[7-(*tert*-butyl-dimethyl-silyloxy)-4-(hydroxy-phenyl)-methyl]-2*H*-chromen-3-yl]-phenol**



The title product was prepared according to the procedure described in Example 26 with substitution of phenyl magnesium bromide as the Grignard reagent for the Grignard reagent 4-[2-(piperidin-1-yl)-ethoxy]-phenyl

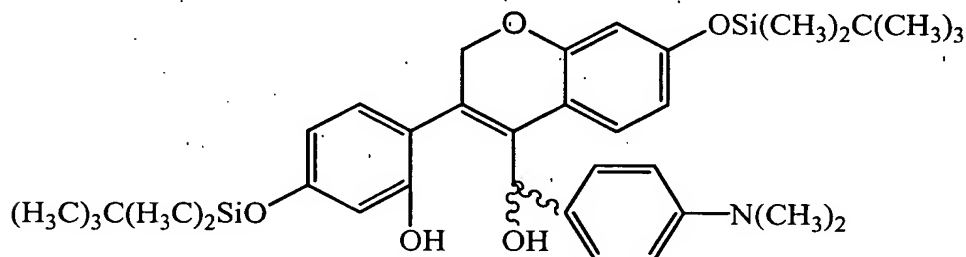
magnesium bromide (generated in situ from 4-[2-(piperidin-1-yl)-ethoxy]-iodobenzene and isopropyl magnesium bromide).

MS (CI)  $m/z$  591 ( $M+H$ )<sup>+</sup>, 613 ( $M+Na$ )<sup>+</sup>, 573 ( $M-H_2O+H$ )<sup>+</sup>; loop negative, 589 ( $M-H$ ).

5

### EXAMPLE 33

#### 5-(*tert*-Butyl-dimethyl-silyloxy)-2-[7-(*tert*-butyl-dimethyl-silyloxy)-4-[(4-dimethylamino-(phenyl)-hydroxy-methyl]-2*H*-chromen-3-yl)]-phenol



10

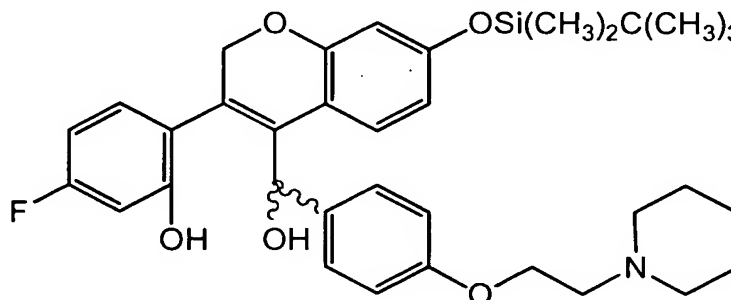
The title product was prepared according to the procedure described in Example 26 with substitution of 4-(dimethylamino)-phenyl magnesium bromide as the Grignard reagent for the Grignard reagent 4-[2-(piperidin-1-yl)-ethoxy]-phenyl magnesium bromide (generated in situ from 4-[2-(piperidin-1-yl)-ethoxy]-iodobenzene and isopropyl magnesium bromide).

15

MS (CI)  $m/z$  634 ( $M+H$ )<sup>+</sup>, 616 ( $M-H_2O+H$ )<sup>+</sup>.

### EXAMPLE 34

#### 2-(7-(*tert*-butyl-dimethyl-silyloxy)-4{hydroxy-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-methyl}-2*H*-chromen-3-yl)-5-fluoro-phenol



20

The title compound was prepared according to the procedure described in Example 26, with substitution of 2-(*tert*-Butyl-dimethyl-silanlyoxy)-8-fluoro-5,11-dihydro-chromeno [4,3-*c*]-chromen-5-ol, prepared as in Example 25, for 2,

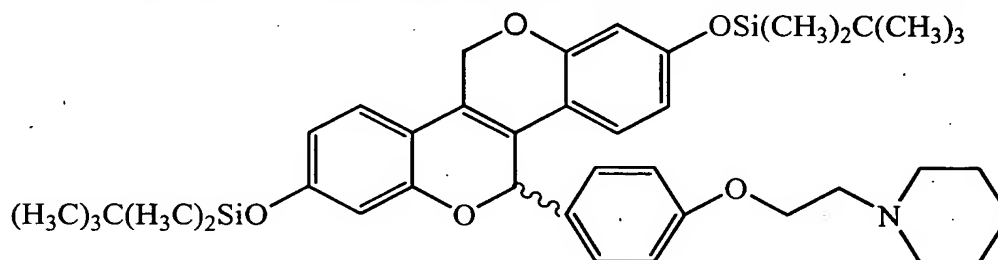
8-bis-(*tert*-Butyl-dimethyl-silanlyoxy)-5,11-dihydro-chromeno [4,3-*c*]-chromen-5-ol.

MS (CI)  $m/z$  606 ( $M+H^+$ ), 648 ( $M+Na$ )<sup>+</sup>; loop negative 604 ( $M-H$ )

5

**EXAMPLE 35**

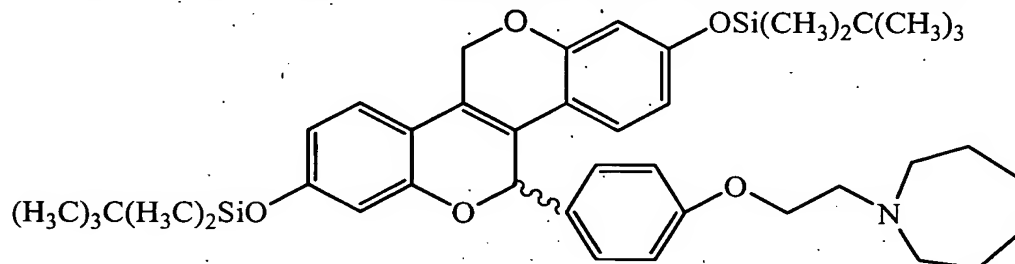
**1-(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-*c*]-chromen-5-yl]-phenoxy}-ethyl)-piperidine Compound #8**



To a stirred solution of 5-(*tert*-butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{hydroxy-[4-(2-piperidine-1-yl-ethoxy)-phenyl]-methyl}-2*H*-chromen-3-yl)-phenol (1.0633 g, 1.48 mmol, 1eq), prepared as in Example 26, in tetrahydrofuran (50 mL) under argon at room temperature were added powdered molecular sieve (4 Å, 0.250 g) and triphenyl phosphine (0.7829 g, 2.99 mmol, 2 eq) followed by diethyl diazodicarboxylate (0.52 g = 0.466 mL, 2.96 mmol). The reaction mixture was let run overnight (about 18 hours). The reaction mixture was evaporated to dryness, triturated with ether and the resulting colorless solid of triphenyl phosphine oxide removed by filtration. The filtrate was evaporated to dryness to yield a residue which was purified by column chromatography on silica gel using 2% methanol in dichloromethane as an eluent to yield the title product as a viscous semisolid.

MS (CI)  $m/z$  700 ( $M+H$ )<sup>+</sup>

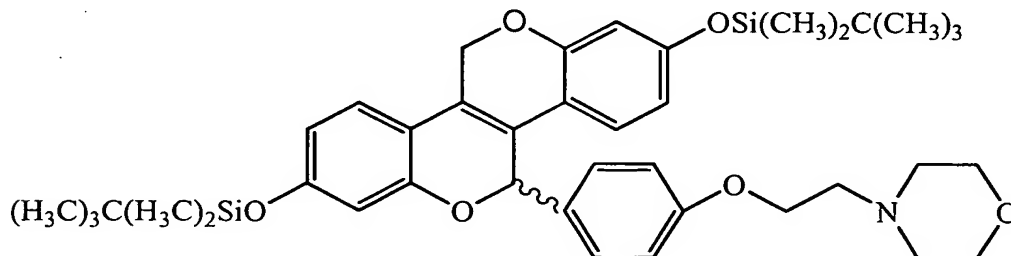
<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.30 (2H, d,  $J$  = 8.7 Hz), 6.87 (1H, d,  $J$  = 8.30 Hz), 6.79 (2H, d,  $J$  = 1.91, 6.82 Hz), 6.70 (1H, d,  $J$  = 8.42 Hz), 6.39 (2H, m), 6.29 (2H, m), 6.14 (1H, s), 5.30 (1H, d,  $J$  = 13.90 Hz), 5.10 (1H, d,  $J$  = 1.654, 13.90 Hz), 4.04 (2H, t,  $J$  = 5.97 Hz), 2.48 (2H, t,  $J$  = 6.0 Hz), 2.48 (4H, m), 1.58 (4H, m), 1.43 (2H, m), 0.95 (9H, s), 0.93 (9H, s), 0.18 (6H, s), 0.16 (6H, s).

**EXAMPLE 36****1-(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]-chromen-5-yl]-phenoxy}-ethyl)-azepane Compound #16**

- 5 The title product was prepared according to the procedure described in Example 35 with substitution of 5-(*tert*-Butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{hydroxy-[4-(2-diethylamino-ethoxy)-phenyl]-methyl}-2*H*-chromen-3-yl)-phenol, prepared as in Example 27 for 5-(*tert*-butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{hydroxy-[4-(2-piperidine-1-yl-ethoxy)-phenyl]-methyl}-2*H*-chromen-3-yl)-phenol.
- 10

MS (CI)  $m/z$  714 ( $M+H$ )<sup>+</sup>.

- <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>):  $\delta$  7.31 (2H, d,  $J$  = 8.72 Hz), 6.87 (1H, d,  $J$  = 8.32 Hz), 6.79 (2H, d,  $J$  = 8.70 Hz), 6.70 (1H, d,  $J$  = 8.44 Hz), 6.14 (1H, s), 5.30 (1H, d,  $J$  = 13.88 Hz), 5.10 (1H, d,  $J$  = 1.55, 13.88 Hz), 4.01 (2H, t,  $J$  = 6.20 Hz), 2.91 (2H, t,  $J$  = 6.20 Hz), 2.81-2.73 (4H, m), 1.70-1.60 (8H, m), 0.95 (9H, s), 0.93 (9H, s), 0.18 (6H, s), 0.16 (6H, s).
- 15

**EXAMPLE 37****1-(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]-chromen-5-yl]-phenoxy}-ethyl)-morpholine Compound #12**

The title product was prepared according to the procedure described in Example 35 with substitution of 2-[4-{[4-(2-Azepan-1-yl-ethoxy)-

phenyl]hydroxymethyl}-7- (*tert*-Butyl-dimethyl-silyloxy)- 2*H*-chromen-3-yl]-5- (*tert*-butyl-dimethyl-silyloxy)-phenol, prepared as in Example 28, for 5-(*tert*-butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{hydroxy-[4-(2-piperidine-1-yl-ethoxy)-phenyl]-methyl}-2*H*-chromen-3-yl)-phenol.

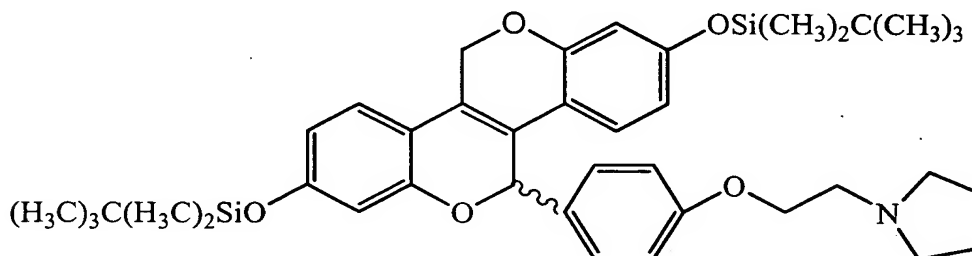
5 MS (CI) *m/z* 702 (M+H)<sup>+</sup>

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.31 (2H, d, *J* = 8.65 Hz), 6.88 (1H, d, *J* = 8.33 Hz), 6.79 (2H, d, *J* = 8.74 Hz), 6.70 (1H, d, *J* = 8.43 Hz), 6.41 – 6.27 (4H, m), 6.15 (1H, brs), 5.30 (1H, d, *J* = 13.77 Hz), 5.10 (1H, d, *J* = 1.52, 13.77 Hz), 4.04 (2H, t), 3.74 – 3.69 (4H, m), 2.75 (2H, t), 2.55-2.52 (4H, m), 0.95 (9H, s), 0.93 (9H, s), 0.18 (6H, s), 0.16 (6H, s).

10

### EXAMPLE 38

#### 1-(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-*c*]-chromen-5-yl]-phenoxy}-ethyl)-pyrrolidine Compound #10



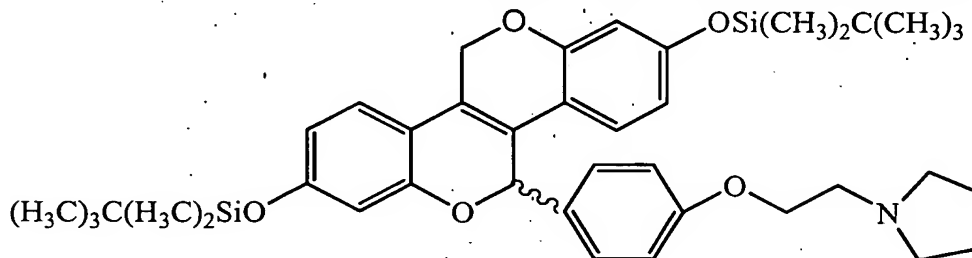
The title product was prepared according to the procedure described in Example 35 with substitution of 5-(*tert*-Butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{hydroxy-[4-(2-pyrrolidine-1-yl-ethoxy)-phenyl]-methyl}-2*H*-chromen-3-yl)-phenol, prepared as in Example 29, for 5-(*tert*-butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{hydroxy-[4-(2-piperidine-1-yl-ethoxy)-phenyl]-methyl}-2*H*-chromen-3-yl)-phenol.

20

MS (CI) *m/z* 686 (M+H)<sup>+</sup>

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.31 (2H, d, *J* = 8.59 Hz), 6.87 (1H, d, *J* = 8.32 Hz), 6.80 (2H, d, *J* = 8.70 Hz), 6.70 (1H, d, *J* = 8.41 Hz), 6.15 (1H, s), 5.30 (1H, d, *J* = 13.88 Hz), 5.10 (1H, d, *J* = 14.04 Hz), 4.05 (2H, t, *J* = 5.88 Hz), 2.87 (2H, t, *J* = 5.98 Hz), 2.61 (4H, brs), 0.95 (9H, s), 0.93 (9H, s), 0.18 (6H, s), 0.16 (6H, s).

25

**EXAMPLE 39****(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]-chromen-5-yl]-phenoxy}-ethyl)-diethylamine Compound #18**

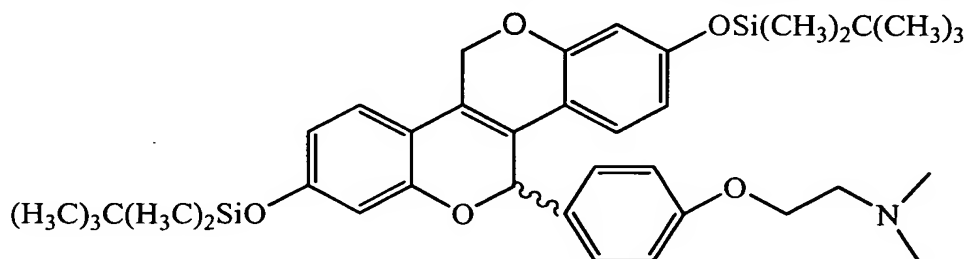
- 5 The title product was prepared according to the procedure described in Example 35 with substitution of 5-(*tert*-Butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{hydroxy-[4-(2-diethylamino-ethoxy)-phenyl]-methyl}-2*H*-chromen-3-yl)-phenol, prepared as in Example 30, for 5-(*tert*-butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{hydroxy-[4-(2-piperidine-1-yl-ethoxy)-phenyl]-methyl}-2*H*-chromen-3-yl)-phenol.

MS (ci)  $m/z$  688 ( $M+H$ )<sup>+</sup>

- <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>):  $\delta$  7.31 (2H, d,  $J$  = 8.59 Hz), 6.87 (1H, d,  $J$  = 8.32 Hz), 6.77 (2H, d,  $J$  = 8.70 Hz), 6.70 (1H, d,  $J$  = 8.42 Hz), 6.41 – 6.27 (4H, m), 6.15 (1H, s), 5.30 (1H, d,  $J$  = 13.85 Hz), 5.10 (1H, d,  $J$  = 13.89 Hz), 3.97 (2H, t,  $J$  = 6.41 Hz), 2.82 (2H, t,  $J$  = 6.39 Hz), 2.60 (4H, q,  $J$  = 7.14 Hz), 1.03 (6H, t,  $J$  = 7.14 Hz), 0.96 (9H, s), 0.93 (9H, s), 0.18 (6H, s), 0.16 (6H, s).

**EXAMPLE 40**

- 20 **(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]-chromen-5-yl]-phenoxy}-ethyl)-dimethylamine Compound #20**



The title product was prepared according to the procedure described in Example 35 with substitution of 5-(*tert*-Butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-



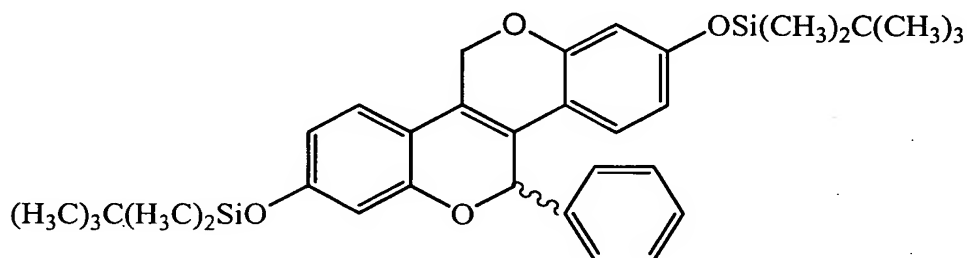
dimethyl-silyloxy)-4-{hydroxy-[4-(2-dimethylamino-ethoxy)-phenyl]-methyl}-2*H*-chromen-3-yl)-phenol, prepared as in Example 31, for 5-(*tert*-butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{hydroxy-[4-(2-piperidine-1-yl-ethoxy)-phenyl]-methyl}-2*H*-chromen-3-yl)-phenol.

5 MS (CI)  $m/z$  660 ( $M+H$ )<sup>+</sup>

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>):  $\delta$  7.31 (2H, d,  $J$  = 8.69 Hz), 6.87 (1H, d,  $J$  = 8.32 Hz), 6.81 (2H, d,  $J$  = 8.68 Hz), 6.70 (1H, d,  $J$  = 8.42 Hz), 6.41 – 6.27 (4H, m), 6.14 (1H, s), 5.30 (1H, d,  $J$  = 13.83 Hz), 4.91 (1H, d,  $J$  = 1.50, 13.88 Hz), 3.99 (2H, t,  $J$  = 5.79 Hz), 2.68 (2H, t,  $J$  = 5.79 Hz), 2.29 (6H, s), 0.95 (9H, s),  
10 0.93 (9H, s), 0.18 (6H, s), 0.16 (6H, s).

#### EXAMPLE 41

##### 2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5-phenyl-5,11-dihydro-chromeno[4,3-*c*]-chromene Compound #5



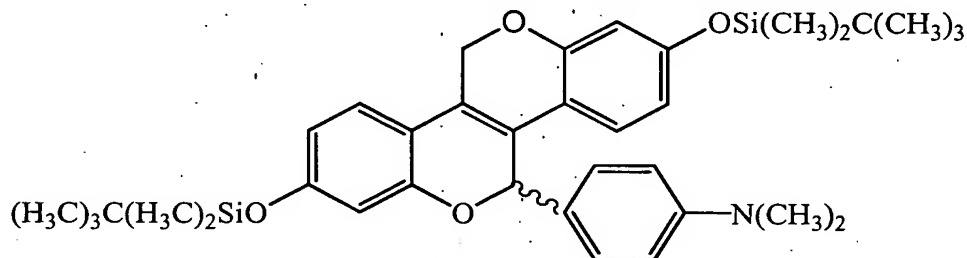
15

The title product was prepared according to the procedure described in Example 35 with substitution of 5-(*tert*-Butyl-dimethyl-silyloxy)-2-[7-(*tert*-butyl-dimethyl-silyloxy)-4-(hydroxy-phenyl)-methyl]-2*H*-chromen-3-yl]-phenol, prepared as in Example 32, for 5-(*tert*-butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{hydroxy-[4-(2-piperidine-1-yl-ethoxy)-phenyl]-methyl}-2*H*-chromen-3-yl)-phenol.

20 MS (CI)  $m/z$  573 ( $M+H$ )<sup>+</sup>, ( $M+Na$ )<sup>+</sup>

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>):  $\delta$  7.41 (2H, m), 7.28 (2H, m), 6.87 (1H, d,  $J$  = 8.30 Hz), 6.54 (1H, d,  $J$  = 8.40 Hz), 6.41 (1H, d,  $J$  = 2.30 Hz), 6.40 (1H, d,  $J$  = 2.34, 7.94 Hz), 6.21 (s, 1H, s), 5.31 (1H, d,  $J$  = 13.90 Hz), 5.10 (1H, d,  $J$  = 1.44, 13.90 Hz), 0.96 (9H, s), 0.93 (9H, s), 0.19 (6H, s), 0.16 (6H, s).

25

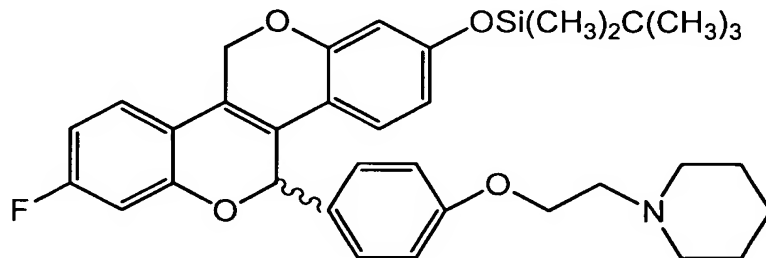
**EXAMPLE 42****2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5-(4-dimethylamino)-phenyl-5,11-dihydro-chromeno[4,3-c]-chromene Compound #23**

5 Crude 5-(*tert*-Butyl-dimethyl-silyloxy)-2-[7-(*tert*-butyl-dimethyl-silyloxy)-4-  
 [(4-dimethylamino-(phenyl)-hydroxy-methyl]-2*H*-chromen-3-yl)]-phenol,  
 prepared as in Example 34, when attempted to purify using silica gel  
 chromatography and ethyl acetate/ hexane as the eluent yielded the title  
 compound as the cyclodehydrated product.

10 MS (CI)  $m/z$  573 ( $M+H$ )<sup>+</sup>, ( $M+Na$ )<sup>+</sup>

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>):  $\delta$  7.41 (2H, m), 7.28 (2H, m), 6.87 (1H, d,  $J$   
 = 8.30 Hz), 6.54 (1H, d,  $J$  = 8.40 Hz), 6.41 (1H, d,  $J$  = 2.30 Hz), 6.40 (1H, d, d,  
 $J$  = 2.34, 7.94 Hz), 6.21 (s, 1H, s), 5.31 (1H, d,  $J$  = 13.90 Hz), 5.10 (1H, d, d,  $J$   
 = 1.44, 13.90 Hz), 2.89 (6H, s), 0.96 (9H, s), 0.93 (9H, s), 0.19 (6H, s), 0.16

15 (6H, s).

**EXAMPLE 43****1-(2-{4-[2-(*tert*-butyl-dimethyl-silyloxy)-8-fluoro-5,11-dihydro-chromeno[4,3c]-chromen-5-yl]-phenoxy}-ethyl)-piperidine Compound #87**

20

The title product was prepared according to the procedure described in  
 Example 26, with substitution of 2-(7-(*tert*-butyl-dimethyl-silyloxy)-4{hydroxy-[4-  
 (2-piperidin-1-yl-ethoxy)-phenyl]-methyl}-2*H*-chromen-3-yl-5-fluoro-phenol,

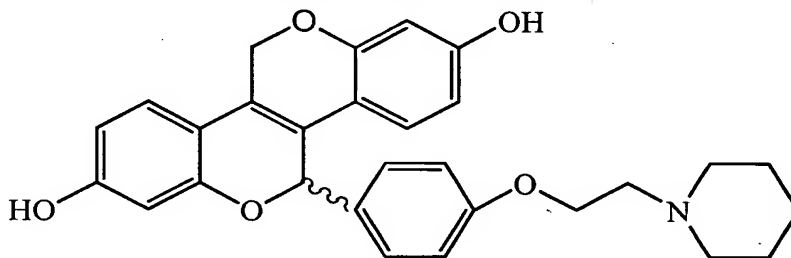
prepared as in Example 34, for 2, 8-bis-(*tert*-Butyl-dimethyl-silanlyoxy)-5,11-dihydro-chromeno [4,3-*c*]-chromen-5-ol.

MS (CI)  $m/z$  588 (M+H)<sup>+</sup>.

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.30 (2H, d, J = 8.67 Hz), 6.94 (1H, ABq, J = 8.49 Hz), 6.80 (2H, d, J = 8.68 Hz), 6.70 (1H, d, J = 8.42 Hz), 6.59 (1H, d, t, J = 2.55, 8.47 Hz), 6.51 (1H, d, d, J = 2.51, 9.82 Hz), 6.41 (1H, d, J = 2.34 Hz), 6.23 (1H, d, d, J = 2.36, 8.37 Hz), 6.18 (1H, s), 5.31 (1H, d, J = 14.07 Hz), 5.08 (1H, d, d, J = 1.37, 13.87 Hz), 4.04 (2H, t, J = 6.02 Hz), 2.73 (2H, t, J = 6.03 Hz), 2.47 (4H, m), 1.88 (4H, m), 1.43 (2H, m), 0.96 (9H, s), 0.19 (6H, s).

#### EXAMPLE 44

##### 5-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydrochromeno[4,3-*c*]chromene-2,8-diol Compound #9



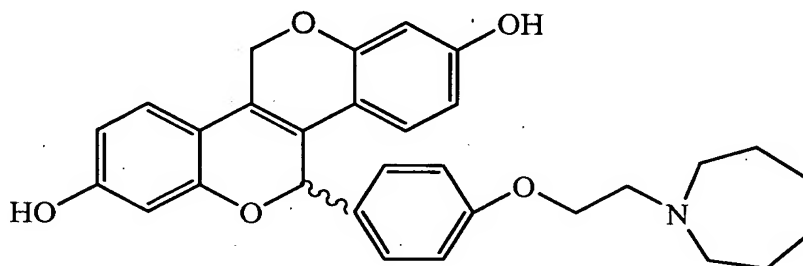
To a stirred solution of 1-(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-*c*]-chromen-5-yl]-phenoxy}-ethyl)-piperidine (0.19 g, 0.2714 mmol, 1 eq), prepared as in Example 35, in tetrahydrofuran (15 mL) under nitrogen was added *tetra*-*n*-butyl ammonium fluoride (1M in tetrahydrofuran, 1.36 mL, 1.36 mmol, 5 eq) and the mixture was stirred for 3 hours. The reaction mixture was diluted with ethyl (30 mL) and then washed with saturated aqueous ammonium chloride solution (35 mL). The precipitated inorganic salts were removed by filtration and washed with ethyl acetate. The combined organic phases were washed with saturated aqueous sodium bicarbonate solution (50 mL), dried (anhydrous sodium sulphate), filtered and evaporated to dryness to yield the crude product. The crude product was purified by column chromatography on silica gel using a 1:1 mixture of hexane and 10% ammoniated methanol containing 10% ammonium hydroxide to yield the purified title product as a brownish, foamy solid.

MS (CI)  $m/z$  472 (M+H)<sup>+</sup>, 470 (M-H, loop negative)

<sup>1</sup>H NMR (300 MHz, d-6 acetone):  $\delta$  8.46 (2H, br hump), 7.24 (2H, d, d, J = 1.93, 6.6 Hz), 6.91 (1H, d, J = 8.40 Hz), 6.71 (3H, d, J = 6.6 Hz), 6.29 (1H, d, d, J = 2.43, 8.34 Hz), 6.25 (1H, d, J = 2.40 Hz), 6.20 (1H, d, d, J = 2.43, 8.32 Hz), 6.13 (2H, d, J = 2.36 Hz), 5.25 (1H, d, J = 14.15 Hz), 4.93 (1H, d, d, J = 1.66, 14.13 Hz), 3.89 (2H, t, J = 6.02 Hz), 2.51 (2H, t, J = 6.02 Hz), 2.30 (4H, m), 1.37 (4H, m), 1.26 (2H, m)

### EXAMPLE 45

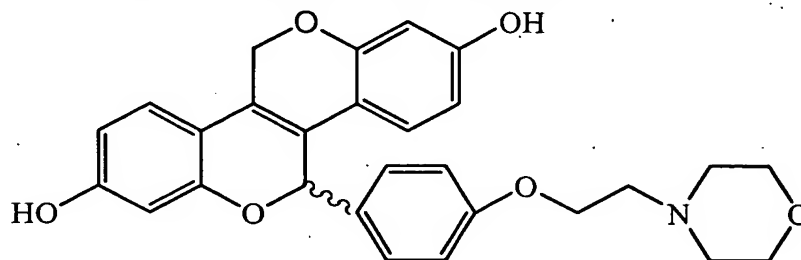
#### 10 5-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-5,11-dihydrochromeno[4,3-c]chromene-2,8-diol Compound #17



The title product was prepared according to the procedure described in Example 44 with substitution of 1-(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]-chromen-5-yl]-phenoxy}-ethyl)-azepane, prepared as in Example 36, for 1-(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]-chromen-5-yl]-phenoxy}-ethyl)-piperidine.

MS (CI)  $m/z$  486 (M+H)<sup>+</sup>; loop negative 484 (M-H)

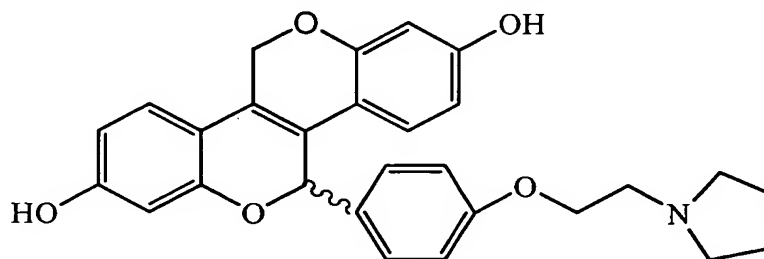
<sup>1</sup>H NMR (300 MHz, d-6 acetone)  $\delta$  7.32 (2H, d, J = 8.70 Hz), 7.03 (1H, d, J = 8.37 Hz), 6.84 (3H, d, J = 8.60 Hz), 6.43 - 6.26 (5H, m), 5.37 (1H, d, J = 14.14 Hz), 5.06 (1H, d, d, J = 1.67, 14.14 Hz), 4.00 (2H, t, J = 6.14 Hz), 2.85 (2H, t, J = 6.11 Hz), 1.56 (8H, m).

**EXAMPLE 46****5-[4-(2-Morpholin-4-yl-ethoxy)-phenyl]-5,11-dihydrochromeno[4,3-c]chromene-2,8-diol Compound #13**

5 The title product was prepared according to the procedure described in Example 44 with substitution of 1-(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]-chromen-5-yl]-phenoxy}-ethyl)-morpholine, prepared as in Example 37, for 1-(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]-chromen-5-yl]-phenoxy}-ethyl)-piperidine.

10 MS (CI)  $m/z$  474 ( $M+H$ )<sup>+</sup>; loop negative 472 ( $M-H$ )

<sup>1</sup>H NMR (300 MHz, d-6 acetone)  $\delta$  8.58 (2H, br hump), 7.37 (2H, d,  $J$  = 8.68 Hz), 7.04 (1H, d,  $J$  = 8.73 Hz), 6.84 (3H, d,  $J$  = 8.73 Hz), 6.42 (1H, d, d,  $J$  = 2.37, 8.34 Hz), 6.38 (2H, d, 2.37 Hz), 6.33 (1H, d, d,  $J$  = 2.41, 8.33 Hz), 6.27 (2H, d,  $J$  = 2.33 Hz), 6.27 (1H, s), 5.38 (1H, d,  $J$  = 14.11 Hz), 5.06 (1H, d, d,  $J$  = 1.56, 14.13 Hz), 4.06 (2H, t,  $J$  = 5.81 Hz), 3.57 (4H, t,  $J$  = 4.01 Hz), 2.92 (4H, brs), 2.69 (2H, t,  $J$  = 3.45).

**EXAMPLE 47****5-[4-(2-Pyrrolidin-1-yl-ethoxy)-phenyl]-5,11-dihydrochromeno[4,3-c]chromene-2,8-diol Compound #11**

20 The title product was prepared according to the procedure described in Example 44 with substitution of 1-(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-

5,11-dihydro-chromeno[4,3-c]-chromen-5-yl]-phenoxy}-ethyl)-pyrrolidine,  
prepared as in Example 38, for 1-(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-  
5,11-dihydro-chromeno[4,3-c]-chromen-5-yl]-phenoxy}-ethyl)-piperidine.

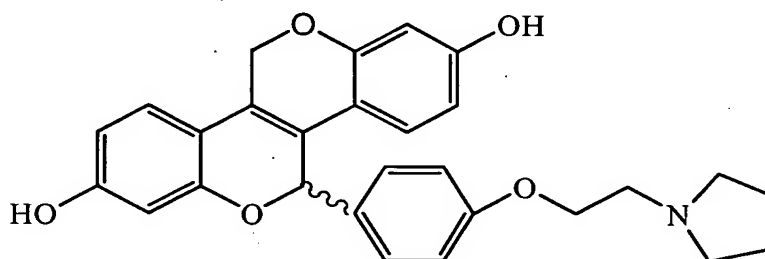
MS (CI)  $m/z$  458 ( $M+H$ )<sup>+</sup>; loop negative 456 ( $M-H$ )

5 <sup>1</sup>H NMR (300 MHz, d-6 acetone)  $\delta$  7.36 (2H, d,  $J$  = 8.63 Hz), 7.01 (1H, d,  $J$  = 8.34 Hz), 6.84 – 6.79 (3H, m), 6.44 – 6.26 (5H, m), 5.36 (1H, d,  $J$  = 14.14 Hz), 5.05 (1H, d,  $J$  = 1.22, 14.13 Hz), 4.82 (2H, br hump), 4.03 (2H, t,  $J$  = 5.85 Hz), 2.81 (2H, t,  $J$  = 5.83), 2.54 (4H, m) 1.71-1.68 (4H, m).

10

### EXAMPLE 48

#### 5-[4-(2-Diethylamino-ethoxy)-phenyl]-5,11-dihydrochromeno[4,3-c]chromene-2,8-diol Compound #19

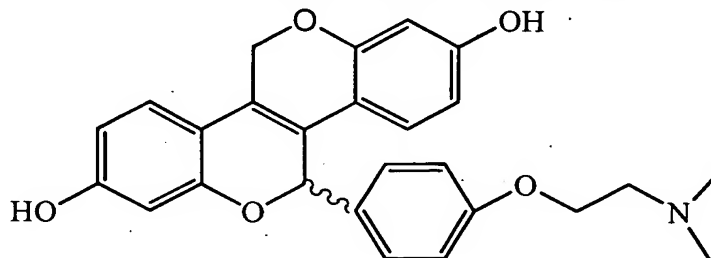


15 The title product was prepared according to the procedure described in  
Example 44 with substitution of (2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-  
dihydro-chromeno[4,3-c]-chromen-5-yl]-phenoxy}-ethyl)-diethylamine, prepared  
as in Example 39, for 1-(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-  
chromeno[4,3-c]-chromen-5-yl]-phenoxy}-ethyl)-piperidine.

MS (CI)  $m/z$  460 ( $M+H$ )<sup>+</sup>; loop negative 458 ( $M-H$ )

20 <sup>1</sup>H NMR (300 MHz, d-6 acetone)  $\delta$  7.36 (2H, d,  $J$  = 8.65 Hz), 7.02 (1H, d,  $J$  = 8.36 Hz), 6.82 (3H, d,  $J$  = 2.34, 8.47), 6.43 – 6.26 (5H, m), 5.50 (2H, br hump), 5.37 (1H, d,  $J$  = 14.12 Hz), 5.06 (1H, d,  $J$  = 1.46, 14.12 Hz), 4.82 (2H, br hump), 3.99 (2H, t,  $J$  = 6.23 Hz), 2.81 (2H, t,  $J$  = 6.16 Hz), 2.57 (4H, q,  $J$  = 7.12 Hz) 0.99 (6H, t,  $J$  = 7.11).

25

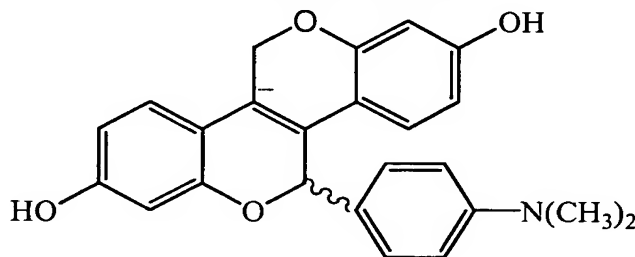
**EXAMPLE 49****5-[4-(2-Dimethylamino-ethoxy)-phenyl]-5,11-dihydrochromeno[4,3-c]chromene-2,8-diol Compound #21**

5 The title product was prepared according to the procedure described in Example 44 with substitution of (2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]-chromen-5-yl]-phenoxy}-ethyl)-dimethylamine, prepared as in Example 40, for 1-(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]-chromen-5-yl]-phenoxy}-ethyl)-piperidine.

10 MS (CI)  $m/z$  432 ( $M+H$ )<sup>+</sup>; loop negative 430 ( $M-H$ )

<sup>1</sup>H NMR (300 MHz, d-6 acetone)  $\delta$  7.37 (2H, d,  $J = 8.63$  Hz), 7.03 (1H, d,  $J = 8.36$  Hz), 6.84 (3H, d,  $J = 8.49$  Hz), 6.43 – 6.27 (5H, m), 5.38 (1H, d,  $J = 14.11$  Hz), 5.06 (1H, d,  $J = 1.39, 14.11$  Hz), 4.02 (2H, t,  $J = 5.88$  Hz), 2.63 (2H, t,  $J = 5.85$  Hz), 2.23 (6H, brs).

15

**EXAMPLE 50****5-[4-Dimethylamino-phenyl]-5,11-dihydro-chromeno[4,3-c]chromene-2,8-diol Compound #26**

20 The title product was prepared according to the procedure described in Example 44 with substitution of 2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5-(4-dimethylamino)-phenyl-5,11-dihydro-chromeno[4,3-c]-chromene, prepared as

in Example 42, for 1-(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-*c*]-chromen-5-yl]-phenoxy}-ethyl)-piperidine.

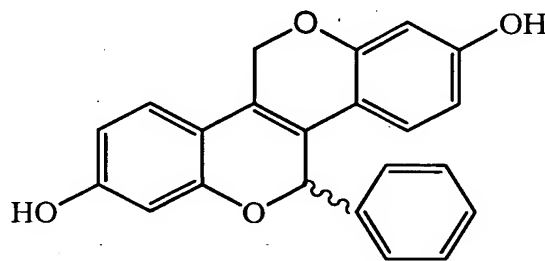
MS (CI)  $m/z$  388 ( $M+H$ )<sup>+</sup>; loop negative 386 ( $M-H$ )

<sup>1</sup>H NMR (300 MHz, d-5 methanol)  $\delta$  7.21 (2H, d,  $J$  = 8.79 Hz), 6.92 (1H, d,  $J$  = 8.36 Hz), 6.71 (1H, d,  $J$  = 8.41 Hz), 6.64 (2H, d,  $J$  = 8.83 Hz), 6.33 (1H, d,  $J$  = 2.42, 7.70 Hz), 6.30 (1H, d,  $J$  = 2.39 Hz), 6.23 (1H, d,  $J$  = 2.43, 8.36 Hz), 6.12 (1H, d,  $J$  = 2.41 Hz), 6.08 (1H, s), 5.26 (1H, d,  $J$  = 13.95 Hz), 5.03 (1H, d,  $J$  = 1.62, 13.95 Hz), 2.86 ((6H, s).

10

### EXAMPLE 51

#### 5-Phenyl-5,11-dihydro-chromeno[4,3-*c*]chromene-2,8-diol: Compound #6



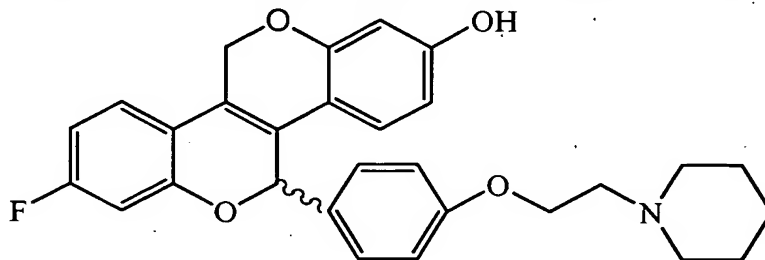
The title product was prepared according to the procedure described in Example 44 with substitution of 2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5-phenyl-5,11-dihydro-chromeno[4,3-*c*]chromene, prepared as in Example 41, for 1-(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-*c*]-chromen-5-yl]-phenoxy}-ethyl)-piperidine.

MS (CI)  $m/z$  345 ( $M+H$ )<sup>+</sup>; loop negative 343 ( $M-H$ .)

<sup>1</sup>H NMR (500 MHz, acetone-*d*<sub>6</sub>):  $\delta$  8.49 (1H, brs), 8.47 (1H, s), 7.46 (2H, d,  $J$  = 1.76, 8.10 Hz), 7.31 – 7.26 (3H, m), 7.04 (1H, d,  $J$  = 8.38 Hz), 6.87 (1H, d,  $J$  = 8.38 Hz), 6.47 (1H, d,  $J$  = 2.43, 8.38 Hz), 6.38 (1H, d,  $J$  = 2.43, 8.38 Hz), 6.33 (1H, brs), 6.29 (1H, d,  $J$  = 2.43), 5.38 (1H, d,  $J$  = 14.08), 5.06 (1H, d,  $J$  = 1.67, 14.08 Hz).

25

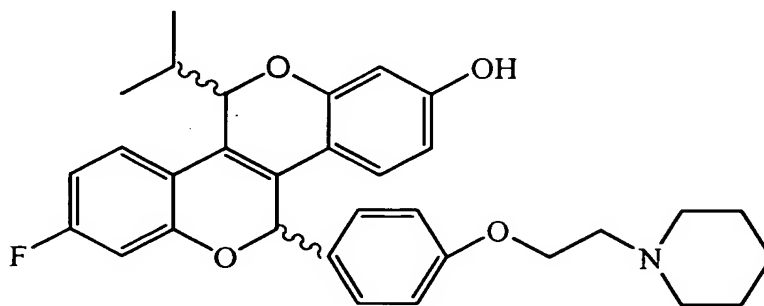


**EXAMPLE 52****8-Fluoro-5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3c]chromen-2-ol Compound #46**

5 The title compound was prepared according to the procedure described in Example 44, with substitution of 1-(2-{-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-8-fluoro-5,11-dihydro-chromeno[4,3c]chromen-5-yl]-phenoxy}-ethyl)-piperidine, prepared as in Example 42 for 1-(2-{4-[2,8-Bis-(*tert*-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]-chromen-5-yl]-phenoxy}-ethyl)-piperidine.

10 MS (CI)  $m/z$  474 ( $M+H$ )<sup>+</sup>; loop negative 472 ( $M-H$ )

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>):  $\delta$  7.24 (2H, d,  $J$  = 8.36 Hz), 7.19 (1H, br hump), 6.90 (1H, ABq,  $J$  = 8.45 Hz), 6.67 (2H, d,  $J$  = 8.66 Hz), 6.62 (2H, d, 8.43), 6.57 (1H, d, d,  $J$  = 2.53, 8.49 Hz), 6.49 (1H, d, d,  $J$  = 2.47, 9.79 Hz), 6.33 (1H, d,  $J$  = 2.24 Hz), 6.14 (1H, s), 5.24 (1H, d,  $J$  = 13.86 Hz), 5.03 (1H, d, 13.19 Hz), 4.00 (2H, t,  $J$  = 5.69 Hz), 2.70 (2H, m), 2.54 (4H, brs), 1.60 (4H, brm), 1.43 (2H, brm).

**EXAMPLE 53****8-Fluoro-11-isopropyl-5-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydrochromeno[4,3-c]chromene-2-ol Compound #47**

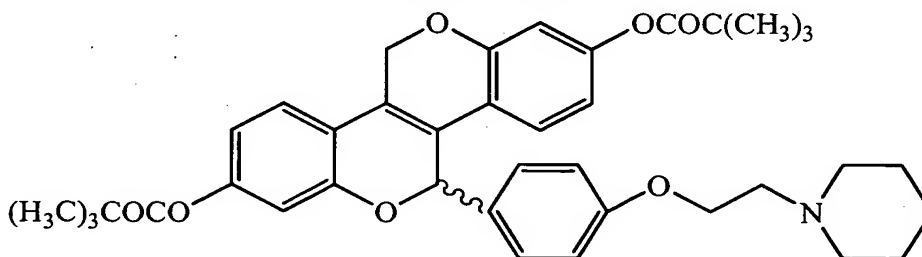
During the purification of the compound prepared in Example 52 by column chromatography, the title compound was isolated in small amount as an accompanying minor component, derived from the silylated precursor [MS (CI) m/z 630, present as a minor side product in the major component prepared as in Example 52, which in turn was derived from a precursor formed as a minor side product during the preparation of the title compound of Example 34, through the side reaction with isopropyl magnesium bromide.

MS (CI) m/z 516 (M+H)<sup>+</sup>; loop negative 514 (M-H)

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.34 (2H, d, J = 8.34 Hz), 7.03 (1H, ABq, J = 8.53 Hz), 6.75 (2H, d, J = 8.79 Hz), 6.61 (2H, d, J = 8.34 Hz), 6.57 (1H, d, 2.40 Hz), 6.50 (1H, d, d, J = 2.61, 6.12 Hz), 6.429 (1H, d, J = 2.40 Hz), 6.24 (1H, d, d, J = 2.42, 8.34 Hz), 6.04 (1H, s), 4.92 (1H, d, 7.30 Hz), 4.08 (2H, t, J = 5.79 Hz), 2.83 (2H, m), 2.59 (4H, brs), 2.28 (1H, m), 1.64 (4H, brm), 1.46 (2H, brm), 1.25 (1H, s), 1.07 (3H, d, J = 6.90 Hz), 1.03 (3H, d, J = 6.54 Hz).

#### EXAMPLE 54

##### 2,2-Dimethyl-propionic acid, 8-(2,2-dimethyl-propionyloxy)-5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester Compound #22



To an ice-cooled and stirred slurry of 5-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydrochromeno[4,3-c]chromene-2,8-diol (0.200g, 0.424 mmol), prepared as in Example 44, in dichloromethane (10 mL) under nitrogen, was added triethylamine (0.2mL, 1.43 mmol, 3.5 eq). After about 10 minutes the reaction mixture was observed to become clear. To the reaction mixture was then slowly added (over a period of about 5 minutes) 2,2-dimethylpropionyl chloride (i.e., pivaloyl chloride, 0.157 mL, 1.3 mmol, 3.18 eq.). The cooling bath was then removed and the reaction mixture was allowed to warm to room

temperature overnight. To the reaction mixture was then added saturated NaHCO<sub>3</sub> solution (20 mL) and the resulting solution was stirred at room temperature for 1 hour. The organic layer was separated and the aqueous layer re-extracted with dichloromethane (2x20 mL). The combined organic  
5 extracts were washed with brine, dried (anhydrous sodium sulphate), filtered and evaporated in vacuo. The residue was purified by chromatography on silica gel using 2% methanol/ dichloromethane as an eluent to yield the title product as an ivory, crystalline solid.

MS (CI) m/z 640 (M+H)<sup>+</sup>

10 <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.30 (2H, d, J = 8.7 Hz), 7.01 (1H, d, J = 8.4 Hz), 6.83 – 6.78 (3H, m), 6.64 (1H, d,d, J = 2.3, 8.5 Hz), 6.63 (1H, d, J = 2.3 Hz), 6.54 – 6.49 (2H, m), 6.21 (1H, s), 5.37 (1H, d, J = 14 Hz), 5.16 (1H, d, J = 14 Hz), 4.05 (2H, t, J = 6.0 Hz), 2.74 (1H, t, J = 6.0 Hz), 2.49 (4H, brs), 1.59 (4H, m), 1.37 (2H, m), 1.32 (9H, s), 1.30 (9H, s)

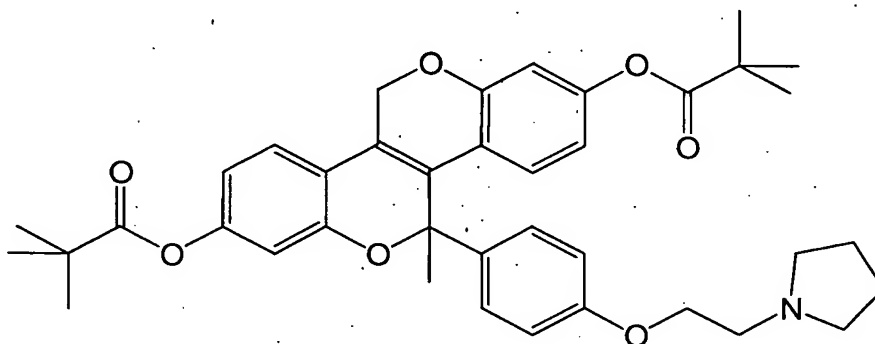
15 IR (KBr): 2972, 2934, 2872, 1754, 1611, 1585, 1510, 1498, 1220, 1175, 1157, 1127, 1109, 1026 cm<sup>-1</sup>

Anal. Calc. C<sub>39</sub>H<sub>45</sub>NO<sub>7</sub>/0.6H<sub>2</sub>O: C, 73.22; H, 7.09; N, 2.19. Found: C, 72.25; H, 7.06; N, 2.08.

20

**EXAMPLE 55**

**2,2-Dimethyl-propionic acid, 8-(2,2-dimethyl-propionyloxy)-5-methyl-5-[4-(2-pyrrolidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester Compound #30**



5

**STEP A: 5-(*tert*-butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{1-hydroxy-1-[4-(2-pyrrolidin-1-yl-ethoxy)-phenyl]-ethyl}-2*H*-chromen-3-yl)-phenol.**

To a solution of 1-[2-(4-bromophenoxy)-ethyl]-pyrrolidine (331mg, 1.22 mmol) in THF (7.5 mL) at  $-78^{\circ}\text{C}$ , was added *n*-butyl lithium (2.5 M in hexane, 478  $\mu\text{L}$ , 1.19 mmol). The mixture was stirred at  $-78^{\circ}\text{C}$  for 0.5 hours. To this mixture was then added 2,8-bis-(*tert*-butyl-dimethyl-silyloxy)-11*H*-chromeno[4,3-*c*]chromen-5-one (153 mg, 0.30 mmol) in THF (3 mL), prepared as in Example 22. The reaction mixture was then stirred at  $-78^{\circ}\text{C}$  for 1.5 hours.

To this mixture was added methyl magnesium bromide (3 M in diethyl ether, 1 mL, 2.99 mmol) at  $-78^{\circ}\text{C}$  and the reaction mixture stirred at room temperature overnight. The reaction was quenched with aqueous  $\text{NH}_4\text{Cl}$  and extracted with ethyl acetate. The organic layer was washed with brine and dried over  $\text{MgSO}_4$ . The solvent was evaporated to yield the crude product as a yellow oil.

The crude product was carried to the next step without further purification.

20

MS  $m/z$  ( $\text{M}^+$ ) = 719

**STEP B: 1-(2-{4-[2,8-bis-(*tert*-butyl-dimethyl-silyloxy)-5-methyl-5,11-dihydro-chromeno[4,3-*c*]chromen-5-yl]-phenoxy}-ethyl)-pyrrolidine.**

25

5-(*Tert*-butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{1-hydroxy-1-[4-(2-pyrrolidin-1-yl-ethoxy)-phenyl]-ethyl}-2*H*-chromen-3-yl)phenol,

prepared as in STEP A above, was dissolved in toluene (8 mL) and treated with diluted HCl (0.4 mL of concentrated HCl: H<sub>2</sub>O = 1:2 v/v). The reaction mixture was vigorously stirred at room temperature for 1.5 h. The mixture was then diluted with water and ethyl acetate. The layers were separated and the organic layer washed successively with saturated NaHCO<sub>3</sub>, brine and dried over MgSO<sub>4</sub>. The desiccant was filtered off, and the filtrate concentrated. Flash chromatography with ethyl acetate:hexane:CH<sub>3</sub>OH (containing 1% NH<sub>4</sub>OH) = 49:49:2 as the eluent to yield the title compound as a light oil.

<sup>1</sup>H NMR (300 MHz; CDCl<sub>3</sub>): δ 0.80 (s, 30 H), 1.72-1.76 (m, 4 H), 1.97 (s, 3 H), 2.59-2.61 (m, 4 H), 2.84 (t, 2H *J* = 5.9), 4.03 (t, 2 H *J* = 5.9), 5.04 (ABq, 2 H, *J*<sub>AB</sub> = 13.8; Δ*v*<sub>AB</sub> = 22 Hz), 6.29 (dd, 1 H, *J* = 2.4, 8.6 Hz), 6.41 (d, 1 H, *J* = 2.2 Hz), 6.52-6.57 (m, 3 H), 6.78 (d, 2 H, *J* = 8.8 Hz), 6.89 (d, 1 H, *J* = 8.4 Hz), 7.38 (d, 2 H, *J* = 8.8 Hz)

MS *m/z* (M<sup>+</sup>) = 700.

**STEP C: 5-methyl-5-[4-(2-pyrrolidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-*c*]chromene-2,8-diol.**

To a solution of 1-(2-{4-[2,8-bis-(*tert*-butyl-dimethyl-silyloxy)-5-methyl-5,11-dihydro-chromeno[4,3-*c*]chromen-5-yl]-phenoxy}-ethyl)-pyrrolidine (84.5 mg, 0.12 mmol) in THF (7 mL) was added tetrabutylammonium fluoride (1M in THF, 241.4 μL, 0.24 mmol). The mixture was stirred at room temperature for 40 min. Saturated NH<sub>4</sub>Cl was added followed by addition of ethyl acetate. The resulting layers were separated, the organic layer was washed with brine, and dried over MgSO<sub>4</sub>. The solvent was evaporated and the residue dried under vacuum for 2h at room temperature to yield the title compound which was carried on to the next step without further purification.

MS *m/z* (M<sup>+</sup>) = 472, (M<sup>-</sup>) = 470.

**STEP D: 2,2-dimethyl-propionic acid 8-(2,2-dimethyl-propionyloxy)-5-methyl-5-[4-(2-pyrrolidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-*c*]chromen-2-yl ester.**

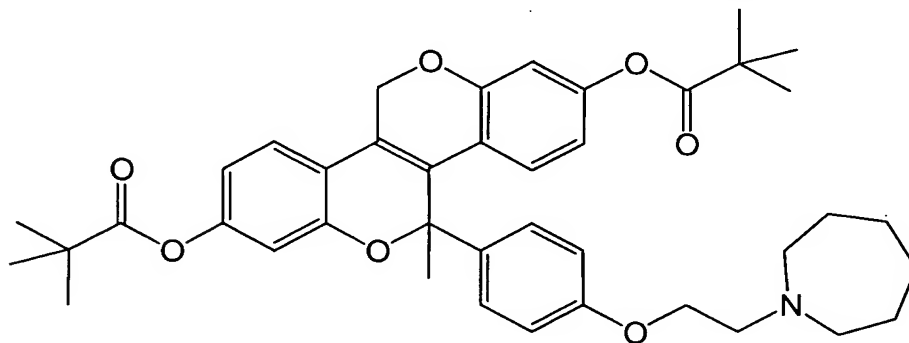
To a suspension of 5-methyl-5-[4-(2-pyrrolidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromene-2,8-diol, prepared as in STEP C above, in dichloromethane (5mL) (DCM) at 5°C was added triethylamine (Et<sub>3</sub>N) (67 mg, 0.66 mmol) and stirred for 5 min. Trimethylacetyl chloride (75.7 mg, 0.63 mmol) was then added to the reaction mixture and the mixture stirred at room temperature overnight. To the reaction mixture was then added saturated NaHCO<sub>3</sub> (10 mL) and the mixture stirred for 1 h. The reaction mixture was then extracted with DCM, washed with brine and dried over MgSO<sub>4</sub>. After removal of the dessicant, the solution was solution was concentrated and the resulting residue eluted through a short silica column with 2% methanol in DCM. The solvent was evaporated to yield the title compounds as a thick yellow oil.

<sup>1</sup>H NMR (300 MHz; CDCl<sub>3</sub>): δ 1.23 (s, 18 H), 1.72-1.76 (m, 4 H), 1.97 (s, 3 H), 2.59-2.61 (m, 4 H), 2.84 (t, 2 H, *J* = 5.9 Hz), 4.03 (t, 2 H, *J* = 5.9 Hz), 5.04 (ABq, 2 H, *J*<sub>AB</sub> = 13.8; Δ*v*<sub>AB</sub> = 22 Hz), 6.29 (dd, 1 H, *J* = 2.4, 8.6 Hz), 6.41 (d, 1 H, *J* = 2.2 Hz), 6.52-6.57 (m, 3 H), 6.78 (d, 2 H, *J* = 8.8 Hz), 6.89 (d, 1 H *J* = 8.4 Hz), 7.38 (d, 2 H, *J* = 8.8 Jz)

MS *m/z* (M<sup>+</sup>) = 640, 662

#### EXAMPLE 56

**11-[4-(2-azepan-1-yl-ethoxy)-phenyl]-8-(2,2-dimethyl-propionyloxy)-11-methyl-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester Compound #33**



**STEP A: 2-[4-{1-[4-(2-azepan-1-yl-ethoxy)-phenyl]-1-hydroxy-ethyl}-7-(tert-butyl-dimethyl-silyloxy)-2*H*-chromen-3-yl]-5-(tert-butyl-dimethyl-silyloxy)-phenol**

To a solution of 1-[2-(4-bromophenoxy)ethyl]-azepane (356 mg, 1.19 mmol) in THF (7.5 mL) at  $-78^{\circ}\text{C}$ , was added n-butyl lithium (2.5 M in hexane, 466  $\mu\text{L}$ , 1.17 mmol). The reaction mixture was stirred at  $-78^{\circ}\text{C}$  for 0.5 hours. To the mixture was then added 2,8-bis-(*tert*-butyl-dimethyl-silyloxy)-11*H*-  
 5 chromeno[4,3-*c*]chromen-5-one, prepared as in Example 22, (149 mg, 0.29 mmol) in THF (3 mL) and the reaction mixture stirred at  $-78^{\circ}\text{C}$  for 1.5 hours. To the mixture was then methyl magnesium bromide (3 M in diethyl ether, 1 mL, 3 mmol) at  $-78^{\circ}\text{C}$  and then stirred at room temperature overnight. The reaction  
 10 was quenched with aqueous  $\text{NH}_4\text{Cl}$  and extracted with ethyl acetate. The organic layer was washed with brine and dried over  $\text{MgSO}_4$ . The remaining solvent was evaporated to yield the crude title product as a yellow oil, which was carried on to the next step without further purification.

MS  $m/z$  ( $\text{M}^+$ ) = 746

15 **STEP B: 1-(2-{4-[2,8-bis-(*tert*-butyl-dimethyl-silyloxy)-5-methyl-5,11-dihydro-chromeno[4,3-*c*]chromen-5-yl]-phenoxy}-ethyl)-azepane**

2-[4-{1-[4-(2-azepan-1-yl-ethoxy)-phenyl]-1-hydroxy-ethyl}-7-(*tert*-butyl-dimethyl-silyloxy)-2*H*-chromen-3-yl]-5-(*tert*-butyl-dimethyl-silyloxy)-phenol, prepared as in STEP A above, was dissolved in toluene (8mL) and treated with  
 20 diluted HCl (0.4 mL of concentrated HCl:  $\text{H}_2\text{O}$  = 1:2 v/v). The reaction mixture was vigorously stirred at room temperature for 1.5 h, then diluted with water and ethyl acetate. The resulting layers were separated and organic layer washed successively with saturated  $\text{NaHCO}_3$ , brine and dried over  $\text{MgSO}_4$ . The desiccant was filtered off, and the filtrate concentrated. Flash  
 25 chromatography with ethyl acetate:hexane: $\text{CH}_3\text{OH}$  (containing 1%  $\text{NH}_4\text{OH}$ ) = 49:49:2 as the eluent yielded the title compound as a light yellow oil.

$^1\text{H}$  NMR (300 MHz;  $\text{CDCl}_3$ ):  $\delta$  0.77 (s, 30 H), 1.52-1.59 (m, 8 H), 1.97 (s, 3 H), 2.71-2.75 (m, 4 H), 2.90 (t, 2 H,  $J$  = 6.0 Hz), 3.99 (t, 2 H  $J$  = 6.0 Hz), 5.04 (ABq, 2 H,  $J_{\text{AB}}$  = 13.8;  $\Delta\nu_{\text{AB}}$  = 22 Hz), 6.29 (dd, 1 H,  $J$  = 2.4, 8.6 Hz), 6.41 (d, 1  
 30 H,  $J$  = 2.2 Hz), 6.53 (m, 3H), 6.77 (d, 2 H,  $J$  = 8.8 Hz), 6.88 (d, 1 H,  $J$  = 8.4 Hz, 7.38 (d, 2 H,  $J$  = 8.8 Hz)

MS  $m/z$  ( $\text{M}^+$ ) = 728.

**STEP C: 5-[4-(2-azepan-1-yl-ethoxy)-phenyl]-5-methyl-5,11-dihydro-chromeno[4,3-c]chromene-2,8-diol**

To a solution of 1-(2-{4-[2,8-bis-(*tert*-butyl-dimethyl-silyloxy)-5-methyl-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-phenoxy}-ethyl)-azepane (77.5 mg, 0.11 mmol) in THF (7 mL) was added tetrabutylammonium fluoride (1M in THF, 213  $\mu$ L, 0.21 mmol). The mixture was stirred at room temperature for 40 min. Saturated  $\text{NH}_4\text{Cl}$  was then added followed by addition of ethyl acetate. The resulting layers were separated, organic layer was washed with brine, and dried over  $\text{MgSO}_4$ . The remaining solvent was evaporated and the residue dried under vacuum for 2 h at room temperature to yield the title compound, which was carried on to the next step without further purification.

MS  $m/z$  ( $M^+$ ) = 472, ( $M^-$ ) = 470

**STEP D: 11-[4-(2-azepan-1-yl-ethoxy)-phenyl]-8-(2,2-dimethyl-propionyloxy)-11-methyl-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester**

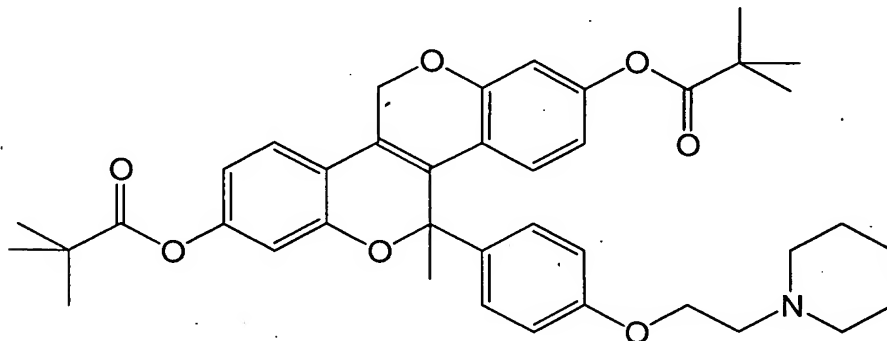
To a suspension of 5-[4-(2-azepan-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromene-2,8-diol, prepared as in STEP C above, in dichloromethane (5mL) (DCM) at 5 °C was added triethylamine (TEA) (59 mg, 0.59 mmol) and stirred for 5 min. To the reaction mixture was then added trimethylacetyl chloride (66.7 mg, 0.55 mmol) and the mixture was then stirred at room temperature overnight. To the reaction mixture was then added saturated  $\text{NaHCO}_3$  (10 mL) and stirred for 1 h. The reaction mixture was extracted with DCM, washed with brine and dried over  $\text{MgSO}_4$ . After removal of the dessicant, the organic solution was concentrated and the residue was purified via silica gel chromatography with 2% methanol in DCM as the eluent, to yield the title compound as a thick yellow oil.

$^1\text{H}$  NMR (300 MHz;  $\text{CDCl}_3$ ):  $\delta$  1.23 (s, 18 H), 1.52-1.59 (m, 8 H), 1.97 (s, 3 H), 2.72-2.75 (m, 4 H), 2.90 (t, 2 H,  $J$  = 6.0 Hz), 3.99 (t, 2 H  $J$  = 6.0 Hz), 5.04 (ABq, 2 H,  $J_{AB}$  = 13.8;  $\Delta\nu_{AB}$  = 22 Hz), 6.29 (dd, 1 H,  $J$  = 2.4, 8.6 Hz), 6.41 (d, 1 H,  $J$  = 2.2 Hz), 6.51-6.56 (m, 3H), 6.77 (d, 2 H,  $J$  = 8.8 Hz), 6.88 (d, 1 H,  $J$  = 8.4 Hz), 7.38 (d, 2 H,  $J$  = 8.8 Hz)



MS  $m/z$  ( $M^+$ ) = 668.**EXAMPLE 57**

**2,2-Dimethyl-propionic acid 8-(2,2-dimethyl-propionyloxy)-11-methyl-11-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester Compound #41**



**STEP A: 5-(*tert*-butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{1-hydroxy-1-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-ethyl}-2*H*-chromen-3-yl)-phenol.**

To a solution of 1-[2-(4-bromophenoxy)-ethyl]-piperidine (360 mg, 1.27 mmol) in THF (7.5 mL) at  $-78^{\circ}\text{C}$ , was added *n*-butyl lithium (1.6 M in hexane, 773  $\mu\text{L}$ , 1.24 mmol). The reaction mixture was stirred at  $-78^{\circ}\text{C}$  for 0.5 hours. To the reaction mixture was then added 2,8-bis-(*tert*-butyl-dimethyl-silyloxy)-11*H*-chromeno[4,3-*c*]chromen-5-one, prepared as in Example 22, (158 mg, 0.31 mmol) in THF (3 mL) and the mixture was stirred at  $-78^{\circ}\text{C}$  for 1.5 hours. To the reaction mixture was then added methyl magnesium bromide (3 M in diethyl ether, 1 mL, 3 mmol) at  $-78^{\circ}\text{C}$  and the reaction stirred at room temperature overnight. The reaction was quenched with aqueous  $\text{NH}_4\text{Cl}$  and extracted with ethyl acetate. The organic layer was washed with brine and dried over  $\text{MgSO}_4$ . The organic layer was concentrated to yield the crude title product as a yellow oil, which was carried into the next step without further purification.

MS  $m/z$  ( $M^+$ ) = 732

**STEP B: 1-(2-{4-[2,8-bis-(*tert*-butyl-dimethyl-silyloxy)-5-methyl-5,11-dihydro-chromeno[4,3-*c*]chromen-5-yl]-phenoxy}-ethyl)-piperidine**

5-(*Tert*-butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{1-hydroxy-1-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-ethyl}-2H-chromen-3-yl)phenol, prepared as in STEP A above, was dissolved in toluene (8mL) and treated with diluted HCl (0.4 mL of concentrated HCl: H<sub>2</sub>O = 1:2 v/v). The reaction mixture was vigorously stirred at room temperature for 1.5 h, then diluted with water and ethyl acetate. The layers were separated and the organic layer washed successively with saturated NaHCO<sub>3</sub>, brine and then dried over MgSO<sub>4</sub>. The desiccant was filtered off, and the filtrate concentrated. Flash chromatography with ethyl acetate:hexane:CH<sub>3</sub>OH (containing 1% NH<sub>4</sub>OH) = 49:49:2 as the eluent yielded the title compound as a light yellow oil.

<sup>1</sup>H NMR (300 MHz; CDCl<sub>3</sub>): δ 0.78 (s, 30 H), 1.33-1.35 (m, 2 H), 1.57-1.63 (m, 4 H), 2.05 (s, 3 H), 2.49-2.51 (m, 4 H), 2.76 (t, 2 H, *J* = 6.0 Hz), 4.08 (t, 2 H, *J* = 6.0 Hz), 5.11 (ABq, 2 H, *J*<sub>AB</sub> = 13.8; Δ*v*<sub>AB</sub> = 31 Hz), 6.37 (dd, 1 H, *J* = 2.4, 8.6 Hz), 6.48 (d, 1 H, *J* = 2.2 Hz), 6.60-6.64 (m, 3H), 6.84 (d, 2 H, *J* = 8.8 Hz), 6.96 (d, 1 H, *J* = 8.4 Hz), 7.44 (d, 2 H, *J* = 8.8 Hz)

MS *m/z* (*M*<sup>+</sup>) = 716, 739.

**STEP C: 5-methyl-5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-*c*]chromene-2,8-diol**

To a solution of 1-(2-{4-[2,8-bis-(*tert*-butyl-dimethyl-silyloxy)-5-methyl-5,11-dihydro-chromeno[4,3-*c*]chromen-5-yl]-phenoxy}-ethyl)-piperidine (54 mg, 0.076 mmol) in THF (7 mL) was added tetrabutylammonium fluoride (1M in THF, 151 μL, 0.15 mmol). The mixture was stirred at room temperature for 40 min. Saturated NH<sub>4</sub>Cl was then added followed by addition of ethyl acetate. The resulting layers were separated; the organic layer was washed with brine, and dried over MgSO<sub>4</sub>. After concentration of the organic layer, the residue was dried under vacuum for 2 h at room temperature to yield the title compound which was carried on to the next step without further purification.

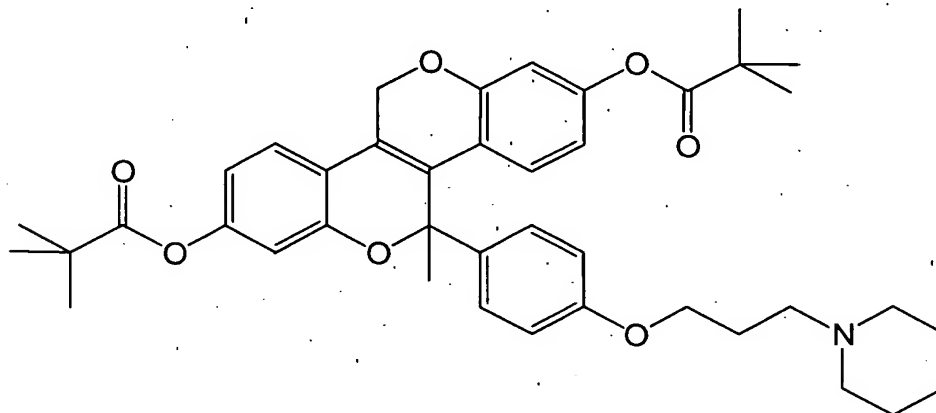
MS *m/z* (*M*<sup>+</sup>) 486, (*M*<sup>-</sup>) 484

**STEP D: 2,2-dimethyl-propionic acid 8-(2,2-dimethyl-propionyloxy)-11-methyl-11-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester**

To a suspension of 5-methyl-5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromene-2,8-diol, prepared as om STEP C above, in dichloromethane (5mL) (DCM) at 5°C was added TEA (42 mg, 0.42 mmol) and the reaction mixture stirred for 5 min. Trimethylacetyl chloride (47 mg, 0.39 mmol) was then added to the reaction mixture and the mixture stirred at room temperature overnight. To the reaction mixture was then added saturated NaHCO<sub>3</sub> (10 mL) and stirred for 1 h. The resulting mixture was extracted with DCM, washed with brine and dried over MgSO<sub>4</sub>. The organic layer was concentrated and the residue was purified via silica gel with 2% methanol in DCM as the eluent, to yield the title compound as a thick yellow oil.

<sup>1</sup>H NMR (300 MHz; CDCl<sub>3</sub>): δ 1.31 (s, 18 H), 1.33-1.35 (m, 2 H), 1.57-1.63 (m, 4 H), 2.05 (s, 3 H), 2.49-2.51 (m, 4 H), 2.76 (t, 2 H, *J* = 6.0 Hz), 4.08 (t, 2 H, *J* = 6.0 Hz), 5.11 (ABq, 2 H, *J*<sub>AB</sub> = 13.8 Hz; Δ*v*<sub>AB</sub> = 31 Hz), 6.37 (dd, 1 H, *J* = 2.4, 8.6 Hz), 6.48 (d, 1 H, *J* = 2.2 Hz), 6.26 (m, 3H), 6.84 (d, 2 H, *J* = 8.8 Hz), 6.96 (d, 1 H, *J* = 8.4 Hz), 7.44 (d, 2 H, *J* = 8.8 Hz)

MS *m/z* (*M*<sup>+</sup>) = 654, 667.

**EXAMPLE 58****2,2-Dimethyl-propionic acid 8-(2,2-dimethyl-propionyloxy)-11-methyl-11-[4-(3-piperidin-1-yl-propoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester. Compound #43**

5

**STEP A: 5-(*tert*-butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{1-hydroxy-1-[4-(3-piperidin-1-yl-propoxy)-phenyl]-ethyl}-2*H*-chromen-3-yl)-phenol.**

To a solution of 1-[3-(4-bromo-phenoxy)-propyl]-piperidine (393 mg, 1.32 mmol) in THF (7.5 mL) at  $-78^{\circ}\text{C}$ , was added *n*-butyl lithium (1.6 M in hexane, 804  $\mu\text{L}$ , 1.29 mmol). The reaction mixture was then stirred at  $-78^{\circ}\text{C}$  for 0.5 hour. To the reaction mixture was then added 2,8-bis-(*tert*-butyl-dimethyl-silyloxy)-11*H*-chromenol[4,3-*c*]chromen-5-one, prepared as in Example 22, (164 mg, 0.32 mmol) in THF (3 mL) and the reaction mixture stirred at  $-78^{\circ}\text{C}$  for 1.5 hours. To the reaction mixture was then added methyl magnesium bromide (3 M in diethyl ether, 1 mL, 3 mmol) at  $-78^{\circ}\text{C}$  and then stirred at room temperature overnight. The reaction was quenched with aqueous  $\text{NH}_4\text{Cl}$  and then extracted with ethyl acetate. The organic layer was washed with brine and dried over  $\text{MgSO}_4$ . After removal of the dessicant, the residue was concentrated to yield the crude title product as a yellow oil, which was carried on to the next step without further purification.

20

MS  $m/z$  ( $\text{M}^+$ ) = 746

**STEP B: 1-(3-{4-[2,8-bis-(*tert*-butyl-dimethyl-silyloxy)-5-methyl-5,11-dihydro-chromenol[4,3-*c*]chromen-5-yl]-phenoxy}-propyl)-piperidine**

5-(*tert*-butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{1-hydroxy-1-[4-(3-piperidin-1-yl-propoxy)-phenyl]-ethyl}-2*H*-chromen-3-yl)-phenol, prepared as in STEP A above, was dissolved in toluene (8mL) and then treated with diluted HCl (0.4 mL of concentrated HCl: H<sub>2</sub>O = 1:2 v/v). The reaction mixture was vigorously stirred at room temperature for 1.5 h. The mixture was then diluted with water and ethyl acetate. The resulting layers were separated and the organic layer washed successively with saturated NaHCO<sub>3</sub>, brine and then dried over MgSO<sub>4</sub>. The desiccant was filtered off, and the filtrate was concentrated. Flash chromatography with ethyl acetate:hexane:CH<sub>3</sub>OH (containing 1% NH<sub>4</sub>OH) = 49:49:2 as the eluent yielded the title compound as a light yellow oil.

<sup>1</sup>H NMR (300 MHz; CDCl<sub>3</sub>): δ 0.78 (s, 30 H), 1.51-1.53 (m, 2 H), 1.78-1.82 (m, 4 H), 2.05 (s, 3 H), 2.14-2.19 (m, 2 H), 2.74-2.79 (m, 4 H), 2.86-2.92 (m; 2 H), 4.00 (t, 2 H, *J* = 5.9 Hz), 5.14 (ABq, 2 H, *J*<sub>AB</sub> = 13.8 Hz; Δ*v*<sub>AB</sub> = 21 Hz), 6.37 (dd, 1 H, *J* = 2.4, 8.6 Hz), 6.48 (d, 1 H, *J* = 2.2 Hz), 6.59-6.64 (m, 3 H), 6.82 (d, 2 H, *J* = 8.8 Hz), 6.97 (d, 1 H, *J* = 8.4 Hz), 7.46 (d, 2 H, *J* = 8.8 Hz)

**STEP C: 5-methyl-5-[4-(3-piperidin-1-yl-propoxy)-phenyl]-5,11-dihydro-chromeno[4,3-*c*]chromene-2,8-diol**

To a solution of 1-(3-{4-[2,8-bis-(*tert*-butyl-dimethyl-silyloxy)-5-methyl-5,11-dihydro-chromenol[4,3-*c*]chromen-5-yl]-phenoxy}-propyl)-piperidine (97.5 mg, 0.134 mmol) in THF (7 mL) was added, tetrabutylammonium fluoride (1M in THF, 268 μL, 0.27 mmol). The reaction mixture was stirred at room temperature for 40 min. To the reaction mixture was then added saturated NH<sub>4</sub>Cl followed by addition of ethyl acetate. The resulting layers were separated, the organic layer was washed with brine, and then dried over MgSO<sub>4</sub>. After concentration of the organic layer, the residue was dried under vacuum for 2 h at room temperature to yield the title compound which was carried on to the next step without further purification.

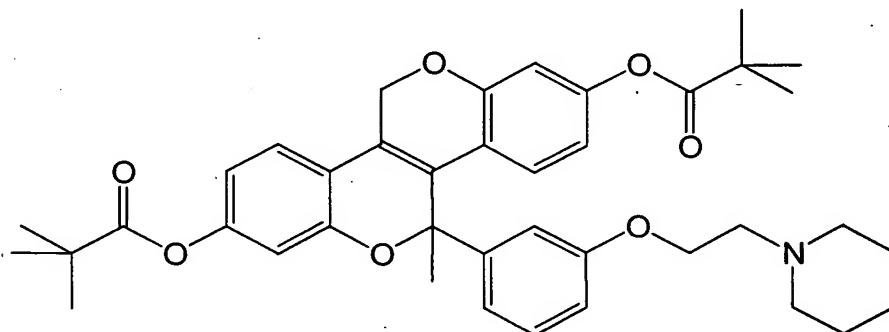
MS *m/z* (*M*<sup>+</sup>) 500, (*M*<sup>-</sup>) 498

**STEP D: 2,2-dimethyl-propionic acid 8-(2,2-dimethyl-propionyloxy)-11-methyl-11-[4-(3-piperidin-1-yl-propoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester**

- 5 To a suspension of 5-methyl-5-[4-(2-piperidin-1-yl-propoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromene-2,8-diol, prepared as in STEP C above, in dichloromethane (5mL) (DCM) at 5°C was added Et<sub>3</sub>N (74.5 mg, 0.74 mmol) and stirred for 5 min. Trimethylacetyl chloride (84 mg, 0.70 mmol) was then added and the reaction mixture stirred at room temperature overnight. To  
10 the reaction mixture was then added saturated NaHCO<sub>3</sub> (10 mL) and then stirred for 1 h. The reaction mixture was then extracted with DCM, washed with brine and dried over MgSO<sub>4</sub>. After removal of the dessicant, the organic layer was concentrated and the resulting residue was purified via silica gel chromatography with 2% methanol in DCM as the eluent to yield the title  
15 compound as a thick yellow oil.

MS m/z (M+H) 668

- <sup>1</sup>H NMR (300 MHz; CDCl<sub>3</sub>): δ 1.30 (s, 18 H), 1.51-1.53 (m, 2 H), 1.78-1.82 (m, 4 H), 2.05 (s, 3 H), 2.14-2.19 (m, 2 H), 2.74-2.79 (m, 4 H), 2.86-2.92 (m, 2 H), 4.00 (t, 2 H, *J* = 5.9 Hz), 5.14 (ABq, 2 H, *J*<sub>AB</sub> = 13.8 Hz; Δ*v*<sub>AB</sub> = 21 Hz),  
20 6.37 (dd, 1 H, *J* = 2.4, 8.6 Hz), 6.48 (d, 1 H, *J* = 2.2 Hz), 6.59-6.64 (m, 3 H), 6.82 (d, 2 H, *J* = 8.8 Hz), 6.97 (d, 1 H, *J* = 8.4 Hz), 7.46 (d, 2 H, *J* = 8.8 Hz)

**EXAMPLE 59****2,2-Dimethyl-propionic acid 8-(2,2-dimethyl-propionyloxy)-11-methyl-11-[3-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester Compound #38**

5

**STEP A: 5-(*tert*-butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{1-hydroxy-1-[3-(2-piperidin-1-yl-ethoxy)-phenyl]-ethyl}-2*H*-chromen-3-yl)-phenol**

To a solution of 1-[3-(4-bromophenoxy)-ethyl]-piperidine (343 mg, 1.21 mmol) in THF (7.5 mL) at  $-78^{\circ}\text{C}$ , was added *n*-butyl lithium (2.5 M in hexane, 471  $\mu\text{L}$ , 1.18 mmol) and the reaction mixture was stirred at  $-78^{\circ}\text{C}$  for 0.5 hours. To the reaction mixture was then added a solution of 2,8-bis-(*tert*-butyl-dimethyl-silyloxy)-11*H*-chromeno[4,3-*c*]chromen-5-one, prepared as in Example 22, (150 mg, 0.29 mmol) in THF (3 mL). The reaction mixture was stirred at  $-78^{\circ}\text{C}$  for 1.5 hours. To the reaction mixture was then added methyl magnesium bromide (3 M in diethyl ether, 1 mL, 3 mmol) at  $-78^{\circ}\text{C}$  and then stirred at room temperature overnight. The reaction was quenched with aqueous  $\text{NH}_4\text{Cl}$  and extracted with ethyl acetate. The organic layer was washed with brine and dried over  $\text{MgSO}_4$ . After removal of the dessicant, the organic layer was concentrated to yield crude the title compound as a yellow oil, which was carried on to the next step without further purification.

15

20

MS  $m/z$  ( $M^+$ ) = 732**STEP B: 1-(2-{3-[2,8-bis-(*tert*-butyl-dimethyl-silyloxy)-5-methyl-5,11-dihydro-chromenol[4,3-*c*]chromen-5-yl]-phenoxy}-ethyl)-piperidine**

25

5-(*Tert*-butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-(1-hydroxy-1-[3-(2-piperidin-1-yl-ethoxy)-phenyl]-ethyl)-2*H*-chromen-3-yl)phenol, prepared as in STEP A above, was dissolved in toluene (8mL) and treated with diluted HCl (0.4 mL of concentrated HCl: H<sub>2</sub>O = 1:2 v/v) and the reaction mixture was vigorously stirred at room temperature for 1.5 h. The reaction mixture was then diluted with water and ethyl acetate. The resulting layers were separated and the organic layer washed successively with saturated NaHCO<sub>3</sub>, brine and then dried over MgSO<sub>4</sub>. The desiccant was filtered off, and the filtrate was concentrated. Flash chromatography with ethyl acetate:hexane:CH<sub>3</sub>OH (containing 1% NH<sub>4</sub>OH) = 49:49:2 as the eluent yielded the title compound as a light yellow oil.

MS m/z (M<sup>+</sup>) 715, 736

**STEP C: 5-methyl-5-[3-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-*c*]chromene-2,8-diol**

To a solution of 1-(2-{3-[2,8-bis-(*tert*-butyl-dimethyl-silyloxy)-5-methyl-5,11-dihydro-chromenol[4,3-*c*]chromen-5-yl]-phenoxy}-ethyl)-piperidine (34 mg, 0.048 mmol) in THF (7 mL) was added, tetrabutylammonium fluoride (1M in THF, 95 µL, 0.095 mmol). The mixture was stirred at room temperature for 40 min. To the reaction mixture was then added saturated NH<sub>4</sub>Cl followed by addition of ethyl acetate. The resulting layers were separated, the organic layer was washed with brine, and then dried over MgSO<sub>4</sub>. The dessicant was filtered off, the organic layer was concentrated and the resulting residue was dried under vacuum for 2 h at room temperature to yield the title compound which was carried on to the next step without further purification.

MS m/z (M<sup>+</sup>) 486, (M<sup>+</sup>) 484

**STEP D: 2,2-dimethyl-propionic acid 8-(2,2-dimethyl-propionyloxy)-11-methyl-11-[3-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-*c*]chromen-2-yl ester**

To a suspension of 5-methyl-5-[3-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-*c*]chromene-2,8-diol, prepared as in STEP C above, in

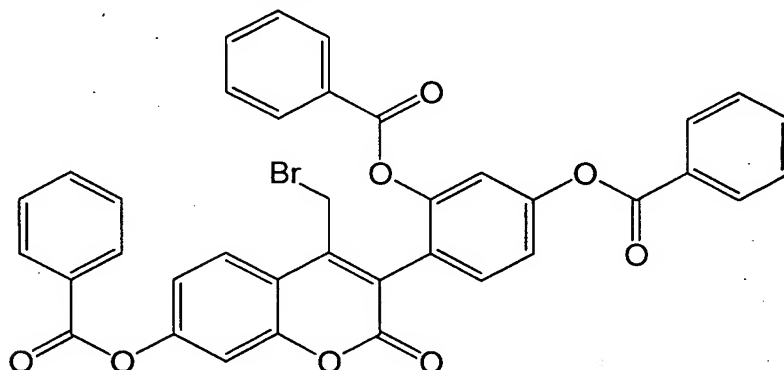


dichloromethane (5mL) (DCM) at 5°C was added Et<sub>3</sub>N (27 mg, 0.26 mmol) and the reaction mixture stirred for 5 min. Trimethylacetyl chloride (30 mg, 0.25 mmol) was then added and the reaction mixture was stirred at room temperature overnight. To the reaction mixture was then added saturated NaHCO<sub>3</sub> (10 mL) and stirred for 1 h. The reaction mixture was then extracted with DCM, washed with brine and dried over MgSO<sub>4</sub>. The dessicant was removed and the organic layer concentrated. The resulting residue was purified via silica gel chromatography with 2% methanol in DCM as the eluent, to yield the title compound as a thick yellow oil.

MS m/z (M<sup>+</sup>) 654

#### EXAMPLE 60

##### 4-Bromomethyl-3-(2,4-dibenzoyl-phenyl)-7-benzoyl-chromen-2-one



LiHMDS (1.0 M, 378  $\mu$ L, 2.5 eq., 0.378 mmol) in THF was added dropwise via syringe into a solution of 3-(2,4-dihydroxy-phenyl)-7-hydroxy-4-methyl-chromen-2-one (90 mg, 1.0 eq., 0.151 mmol) in THF (1 mL) at -78°C under N<sub>2</sub>. The reaction mixture was observed to turn a reddish color. After addition, the reaction mixture was stirred for an additional 0.5h at -78°C. To the reaction mixture, was then added bromine (12  $\mu$ L, 1.5 eq., 0.227 mmol) at 78°C. The color of the mixture was observed to turn from red to light yellow. The reaction mixture was then stirred for an additional 0.5h at -78°C. The reaction was quenched with saturated NaHSO<sub>3</sub> solution, warmed to room temperature and stirred vigorously at room temperature for 15 min. THF was removed by rotavap in vacuo. Ethyl acetate (20 mL) and water (5 mL) were

then added to the reaction residue, resulting in two phases. The aqueous phase was extracted twice with ethyl acetate. The combined organic layer was washed with brine, dried over anhydrous  $\text{Na}_2\text{SO}_4$ , filtered and concentrated to yield the crude title compound as a yellow solid. The crude material was

5 purified by flash column chromatography using hexanes and ethyl acetate at 3:1 solution as eluent to yield the title compound as a light yellow solid.

The product was determined to contain the benzoic acid 3-benzoyloxy-4-(7-benzoyloxy-4-bromomethyl-2-oxo-2H-chromen-3-yl)-phenyl ester compound and the benzoic acid, 3-benzoyloxy-4-(7-benzoyloxy-4-dibromomethyl-2-oxo-

10 2H-chromen-3-yl)-phenyl ester.

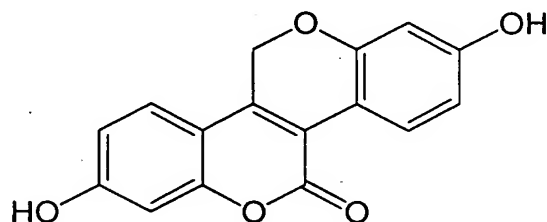
$R_f = 0.60$  in 3:1 hexane:ethyl acetate (UV)

$^1\text{H}$  NMR ( $\text{CDCl}_3$ , TMS standard), 8.22 (m,  $J = 14.4$  Hz, 5H), 8.04 (d,  $J = 6.9$  Hz, 1H), 7.85 (d,  $J = 9.6$  Hz, 1H), 7.69 (m, 4H), 7.42 (m, 5H), 7.30 (m, 5H), 4.48 (ABq,  $J = 10.8$  Hz, 2H)

15 MS ( $M+1$ ), 699, 697.

### **EXAMPLE 612,8-Dihydroxy-11H-chromeno[4,3-c]chromen-5-one**

#### **Compound #1**



#### 20 **Method C:**

4-Bromomethyl-3-(2,4-dibenzoyl-phenyl)-7-benzoyl-chromen-2-one (67 mg, 1.0 eq., 0.099 mmol) was dissolved in acetone (1 mL) and methanol (0.5 mL) under  $\text{N}_2$ .  $\text{K}_2\text{CO}_3$  (41 mg, 3.0 eq., 0.298 mmol) powder was then added in one portion into the solution. The reaction mixture was stirred at room

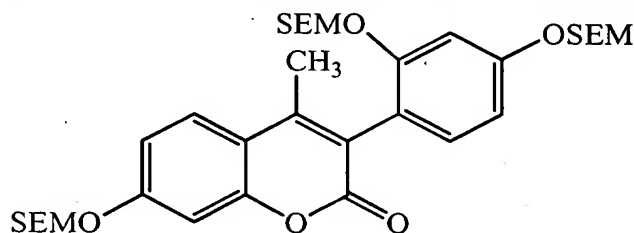
25 temperature overnight. The color of the reaction was observed to turn from light yellow to orange. The solvent was removed, the residue was dissolved in water and the resulting mixture acidified to about pH 1 by drop-wise addition of 6 N HCl.  $\text{CH}_2\text{Cl}_2$  was added into the reaction mixture and the aqueous phase was extracted with  $\text{CH}_2\text{Cl}_2$  twice. The combined organic layer was washed with

water and brine, dried over anhydrous  $\text{Na}_2\text{SO}_4$ , filtered and concentrated to yield crude title compound as a brown solid. A 5:1 mixture of hexane:ethyl acetate was added to the crude product. The supernatant solution was removed by a pipet and the remaining insoluble solid was dried in vacuo to yield the title compound as a solid.

$R_f = 0.2$ , hexane:ethyl acetate = 3:1, UV

### EXAMPLE 62

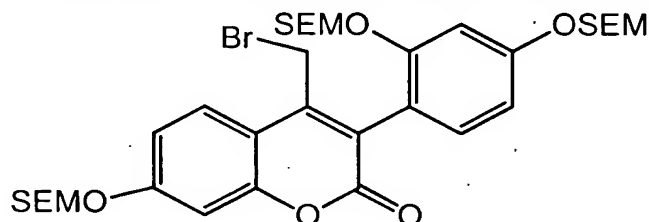
#### 3-[2,4-Bis-(2-trimethylsilyl-ethoxymethoxy)-phenyl]-4-methyl-7-(2-trimethylsilyl-ethoxymethoxy)-chromen-2-one



A mixture of 3-(2,4-dihydroxyphenyl)-7-hydroxy-4-methyl-chromen-2-one (4.7g, 16.5 mmol), SEMCl (14.6 ml, 82.9 mmol) and  $\text{K}_2\text{CO}_3$  (18.6g, 367.1 mmol) in acetone (600 mL) was heated to  $50^\circ\text{C}$  under nitrogen for 1 hour. The resulting mixture was cooled, filtered and evaporated to form a thick oil. The oil was purified by  $\text{SiO}_2$  using 5-10 ethyl acetate/hexane as solvent gradient to yield the title compound as an oil.

MS(Cl)  $m/z$  675 ( $\text{M}+\text{H}$ )<sup>+</sup>, 697 ( $\text{M}+\text{Na}$ )<sup>+</sup>

$^1\text{H}$ -NMR( $\text{CDCl}_3$ , 300 MHz)  $\delta$ (ppm) 7.6(d,  $J=6\text{Hz}$ , 1H), 7.2-6.8(m, 5H), 5.1-5.4(m, 6H), 3.6-3.9(m, 6H), 2.25(s, 3H), 0.2- -0.1(m, 27H).

**EXAMPLE 63****3-[2,4-Bis-(2-trimethylsilyl-ethoxymethoxy)-phenyl]-4-bromomethyl-7-(2-trimethylsilyl-ethoxymethoxy)-chromen-2-one**

5 A 250 mL 3-neck round bottom flask was equipped with a magnetic stirrer, a rubber stopper and an argon inlet/outlet adapter. This vessel was charged with THF (20 mL) *via* syringe,  $i\text{Pr}_2\text{NH}$  (1.8 mL, 14.0 mmol) *via* syringe and cooled to  $-10^\circ\text{C}$  in an ice/methanol bath. *n*-Butyl lithium (1.85 M (titrated) *via* syringe, 6.3 mL, 11.7 mmol) in hexane was added dropwise *via* syringe at

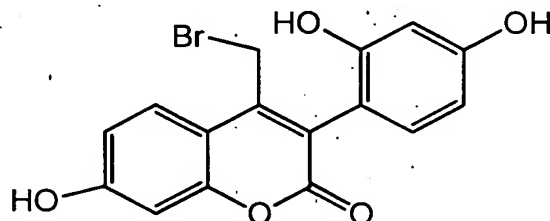
10  $-10^\circ\text{C}$ , stirred for 15 min at  $-10^\circ\text{C}$ . To the solution was added 3-[2,4-bis-(2-trimethylsilyl-ethoxymethoxy)-phenyl]-4-methyl-7-(2-trimethylsilyl-ethoxymethoxy)-chromen-2-one (5.1 g, 7.8 mol) in THF (20 mL) drop-wise *via* syringe. The mixture was stirred at  $-10^\circ\text{C}$  for 2.5 h. This mixture was added dropwise *via* syringe to a solution of  $\text{Br}_2$  (0.76 mL, 2 eq) in  $-78^\circ\text{C}$  THF (100 mL)

15 *via* syringe that was contained in a 1-L 3-neck round bottom flask equipped with mechanical stirrer and septum under  $\text{N}_2$ . After the addition was complete, the mixture was stirred for 5 min at  $-78^\circ\text{C}$  and then diluted with EtOAc (0.5 L) *via* syringe, saturated  $\text{NaHCO}_3$  (50 mL) *via* syringe and saturated  $\text{Na}_2\text{SO}_3$  (100 mL) *via* syringe. The dry ice/acetone bath was removed and the mixture was

20 allowed to warm to room temperature while stirring. The organic phase was separated and the aqueous phase was back-extracted with EtOAc (2 X 0.2 L). The combined organic phase was washed with brine (2 X 0.5 L) and concentrated *in vacuo* to yield the title compound as a crude semi-solid.

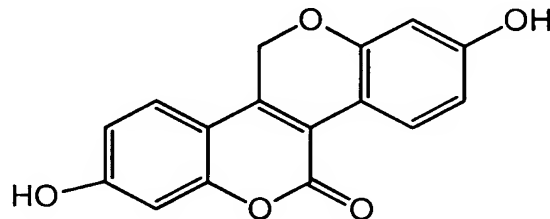
MS  $M/z$   $M+H=770$ ;  $M+Na=793$

25  $^1\text{H-NMR}(\text{CDCl}_3, 300 \text{ MHz}) \delta(\text{ppm})$ : 7.8-6.8 (m, 6H), 5.6-5.1 (m, 6H), 4.4-4.2 (Abq,  $J=16\text{Hz}$ , 2H), 3.8-3.6 (m, 6H), 0.8 - 0.11 (m, 6H)

**EXAMPLE 64****3-[2,4-Bis-(2-trimethylsilyl-ethoxymethoxy)-phenyl]-4-methyl-7-(2-trimethyl silyl-ethoxymethoxy)-chromen-2-one**

5 Into 1N HCl (10 mL) (1N HCl solution made using concentrated HCl in 1:1 THF:IPA) was dissolved 3-[2,4-bis-(2-trimethylsilyl-ethoxymethoxy)-phenyl]-4-bromomethyl-7-(2-trimethylsilyl-ethoxymethoxy)-chromen-2-one (200 mg, 0.544 mmol) and the resulting mixture was stirred for 24h at room temperature. The reaction mixture was then diluted with EtOAc (100 mL) and  
 10 the organic layer washed with water (2 X 20 mL) and brine (30 mL). The organic layer was dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and the organic solvent evaporated to yield the title compound, 3-[2,4-Bis-(2-trimethylsilyl-ethoxymethoxy)-phenyl]-4-methyl-7-(2-trimethyl silyl-ethoxymethoxy)-chromen-2-one as a crude solid.

15 MS(Cl) m/z 362(M+H<sup>+</sup>); 384 (M+Na<sup>+</sup>)  
<sup>1</sup>H-NMR(CDCl<sub>3</sub>, 300 MHz) δ(ppm): 7.8-6.8 (m, 6H), 4.8-4.6 (Abq, J= 14.6 Hz, 2H).

**EXAMPLE 65****2,8-Dihydroxy-11H-chromeno[4,3-c]chromen-5-one Compound #1****Method D:**

2,8-Dihydroxy-11H-chromeno[4,3-c]chromen-5-one( 90 mg, 0.25 mmol) was dissolved in MeOH (2.5mL). K<sub>2</sub>CO<sub>3</sub> (35 mg, 0.2 mmol) was added and the  
 25 resulting mixture was stirred for 10 min at room temperature. The reaction

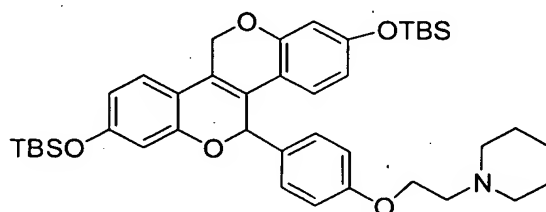
mixture was diluted with EtOAc (50 mL), filtered and the organic solvent evaporated to dryness. The semisolid obtained was purified SiO<sub>2</sub> using 50% EtOAc in hexanes to yield the title compound as a solid.

MS(Cl) m/z 283 (M+H<sup>+</sup>), 306 (M+Na<sup>+</sup>)

5

### EXAMPLE 66

#### 1-(2-[4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-phenoxy]-ethyl)-piperidine



#### 10 Method B:

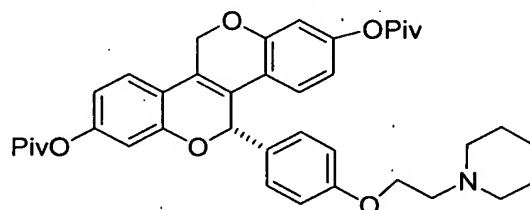
1-[2-(4-Iodo-phenoxy)-ethyl]-piperidine (1.656, 5 mmol) was dissolved in THF and cooled to -78°C. To the reaction mixture, was then added n-butyl lithium (2M solution in pentane, 2.5mL, 10 mmol), slowly over 5 min. The resulting solution was stirred for 1h at -78°C. 2,8-Bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-ol (1.953 mmol) was dissolved in THF (20 mL) and then added to the reaction mixture containing 1-[2-(4-Iodo-phenoxy)-ethyl]-piperidine and n-butyl lithium, slowly over 10 min. The reaction mixture was stirred for an additional hour. The reaction mixture was quenched with MeOH (1mL) and then treated with a saturated solution of ammonium chloride (30 mL) and then diluted with diethyl ether (150 mL). The organic layer was separated and washed with brine (100 mL). The organic layer was dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>, filtered and the solvent evaporated to yield a crude oil. The crude oil was diluted with toluene (150 mL) and HCl (37%, 6.0 mL) and stirred for 30 min at room temperature. The solution was diluted with EtOAc (300 mL), the organic layer washed twice with water (100 ml) and then with a saturated solution of NaHCO<sub>3</sub> (150 ml). The organic layer was separated and dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>, filtered, and evaporated to yield the title compound as a foamy material.

MS(Cl) m/z 700 (M+H<sup>+</sup>), 723 (M+Na<sup>+</sup>)

$^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$ : 7.30 (2H, d,  $J$  = 8.7 Hz), 6.87 (1H, d,  $J$  = 8.30 Hz), 6.79 (2H, d,  $J$  = 1.91, 6.82 Hz), 6.70 (1H, d,  $J$  = 8.42 Hz), 6.39 (2H, m), 6.29 (2H, m), 6.14 (1H, s), 5.30 (1H, d,  $J$  = 13.90 Hz), 5.10 (1H, d,  $J$  = 1.654, 13.90 Hz), 4.04 (2H, t,  $J$  = 5.97 Hz), 2.48 (2H, t,  $J$  = 6.0 Hz), 2.48 (4H, m), 1.58 (4H, m), 1.43 (2H, m), 0.95 (9H, s), 0.93 (9H, s), 0.18 (6H, s), 0.16 (6H, s).

**EXAMPLE 67**

**2,2-Dimethyl-propionic acid 8-(2,2-dimethyl-propionyloxy)-5*S*\*-(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester**



1 M TBAF (in THF, 17 mL, 17 mmol, 3 eq.) was added drop-wise into a solution of 1-(2-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-phenoxy}-ethyl)-piperidine (4.0 g, 5.7 mmol) in THF (40 mL) at  $-10^\circ\text{C}$ . The reaction mixture was stirred for 15 minutes. To the reaction mixture was then added 2,2-dimethylpropionic acid chloride (2.5 mL, 20 mmol, 3.5 eq). The reaction mixture was diluted with ethyl acetate and washed with 5% sodium bicarbonate and then with brine. The organic layer was dried over anhydrous  $\text{Na}_2\text{SO}_4$ , and concentrated to yield a 1:2 mixture of mono-pivalate:di-pivalate. To the crude product dissolved in  $\text{CH}_2\text{Cl}_2$ , was added 2,2-dimethylpropionic acid chloride (4.3 mL) and triethylamine (5 mL) and the reaction mixture was stirred for 30 min. The reaction mixture was diluted with ethyl acetate (300 mL) and then washed with brine. Flash chromatography on Biotage column eluted with 2% to 5% MeOH in  $\text{CH}_2\text{Cl}_2$  yielded the title product as a racemic mixture of 2,2-dimethyl-propionic acid 8-(2,2-dimethyl-propionyloxy)-5[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester.

The racemic compound (2,2-dimethyl-propionic acid 8-(2,2-dimethyl-propionyloxy)-5[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester) (2.5g) was loaded onto a ChiralPak AD chiral HPLC column ( 5 cm I.D. x 50 cm L) and eluted with 20%MeOH in IPA at the 90 mL/min flow rate. The two peaks were removed under vacuum to yield: 2,2-dimethyl-propionic acid 8-(2,2-dimethyl-propionyloxy)-5*R*\*-(-)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester as peak one and 2,2-dimethyl-propionic acid 8-(2,2-dimethyl-propionyloxy)-5*S*\*-(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester as peak two.

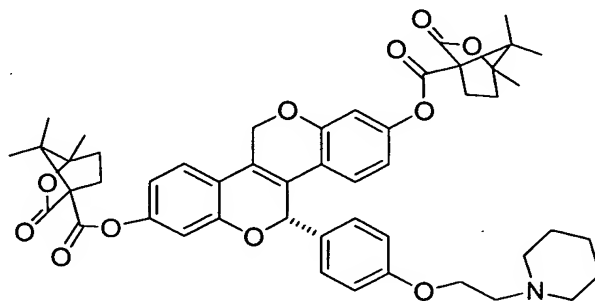
MS  $m/z$  640 ( $M+H^+$ ), 663 ( $M+Na^+$ )

$^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  7.30 (2H, d,  $J = 8.7$  Hz), 7.01 (1H, d,  $J = 8.4$  Hz), 6.83 – 6.78 (3H, m), 6.64 (1H, d,  $J = 2.3, 8.5$  Hz), 6.63 (1H, d,  $J = 2.3$  Hz), 6.54 – 6.49 (2H, m), 6.21 (1H, s), 5.37 (1H, d,  $J = 14$  Hz), 5.16 (1H, d,  $J = 14$  Hz), 4.05 (2H, t,  $J = 6.0$  Hz), 2.74 (1H, t,  $J = 6.0$  Hz), 2.49 (4H, brs), 1.59 (4H, m), 1.37 (2H, m), 1.32 (9H, s), 1.30 (9H, s)

### EXAMPLE 68

(1*S*)-(-)-camphanic acid- 8-((1*S*)-(-)-camphanyl)-5*S*\*-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,1,1-dihydro-chromeno[4,3-c]chromen-2-yl ester

#### Compound #49



1 M TBAF (in THF, 8.5 mL, 8.5 mmol, 3 eq.) was added drop-wise into a solution of 1-(2-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-phenoxy}-ethyl)-piperidine (2.00 g, 2.85 mmol) in THF (30 mL) at  $-10^\circ C$  and the reaction mixture stirred for 15 min. To the reaction mixture, was then added (1*S*)-(-)-camphanic chloride (1.69 g, 8.6



mmol, 3 eq). The reaction mixture was then diluted with ethyl acetate (300 mL) and washed with 5% sodium bicarbonate, then washed with brine. The organic layer was dried over anhydrous  $\text{Na}_2\text{SO}_4$  and concentrated to yield a 1:3 mixture of the mono-camphane:di-camphane derivative.

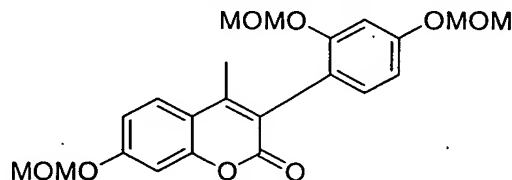
5           To the crude product in  $\text{CH}_2\text{Cl}_2$  (55 mL) was added (1*S*)-(-) camphanic chloride (1.5 g) and TEA (2.0 mL) and the reaction mixture was stirred for 30 minutes at room temperature. The reaction mixture was then diluted with ethyl acetate (250 mL) and then washed with brine. Flash chromatography on  $\text{SiO}_2$  column eluted with 2% to 5% MeOH in  $\text{CH}_2\text{Cl}_2$  yielded the title compound as a  
10       diastereomer mixture of (1*S*)-(-)-camphanic acid-8-((1*S*)-(-)-camphanyl)-5*S*<sup>\*</sup>-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,1,1-dihydro chromeno [4,3-*c*]chromen-2-yl ester and (1*S*)-(-)-camphanic acid-8-((1*S*)-(-)-camphanyl)-5*R*<sup>\*</sup>-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,1,1-dihydro chromeno [4,3-*c*]chromen-2-yl ester.

15           The mixture of diastereomers was suspended in hot ethanol (110 mL) in presence of (*R*)-(-)-10 camphorsulphonic acid (0.6 eq.) and stirred at 70°C for 4 h until the solution became clear. The solution was filtered and cooled to room temperature. A solid was formed after 64h, the solid was filtered and dried under vacuum to yield the title compound as a solid. (84% de)

20           MS *m/z* 832 ( $\text{M}+\text{H}^+$ ); 854 ( $\text{M}+\text{Na}^+$ )

<sup>1</sup>H-NMR( $\text{CDCl}_3$ , 300 MHz)  $\delta$ (ppm): 7.3 (d, *J*=8.3 Hz, 2H), 7.1 (d, *J*= 8.7 Hz, 2H), 7.7-7.8 (m, 3H), 6.7-6.5 (m, 4H), 6.21 (s, 1H), 5.4-5.2 (Abq, *J* =14.4Hz, 2H), 4.1 (t, *J*= 3Hz, 2H), 2.75 (t, *J*=6hz, 2H), 2.29-1.5 (m, 18H), 1.2-0.8 (m, 18H)

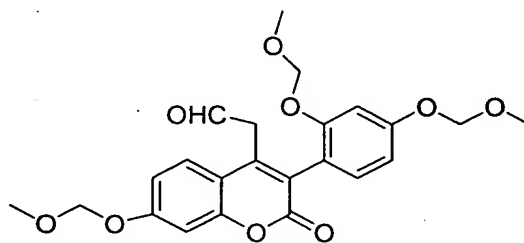
25

**EXAMPLE 69****3-(2,4-Bis-methoxymethoxy-phenyl)-7-methoxymethoxy-4-methyl-chromen-2-one**

5 MOMCl (6.62 ml, 82.9 mmol) was added to the mixture of  $K_2CO_3$  (18.6g, about 367.1 mmol) and 3-(2,4-dihydroxyphenyl)-7-hydroxy-4-methyl-chromen-2-one (4.7g, 16.5 mmol) in acetone (600 ml) at  $0^\circ C$  under nitrogen for 1 hour. The reaction mixture was then stirred for 4h, over which time the solution was allowed to warm to room temperature. The reaction mixture was then filtered  
10 and evaporated to yield a thick oil. The oil was purified by  $SiO_2$  using 5-10 Ethyl acetate:hexane as solvent gradient to yield 3-(2,4-Bis-methoxymethoxy-phenyl)-7-methoxymethoxy-4-methyl-chromen-2-one as a solid.

MS m/e 417 ( $M+H^+$ ) and 439 ( $M+Na^+$ )

$^1H$ -NMR( $CDCl_3$ , 300 MHz)  $\delta$  (ppm): 7.7 (d, 6.7 Hz, 1H), 7.1-6.6 (m, 5H),  
15 5.3-5.1 (m, 6H), 3.411 (s, 3H), 3.41 (s, 3H), 3.3 (s, 3H), 2.2 (s, 3H)

**EXAMPLE 70****[3-(2,4-Bis-methoxymethoxy-phenyl)-7-methoxymethoxy-2-oxo-2H-chromen-4-yl]-acetaldehyde**

20 To a clean dry 200 ml flask purged with nitrogen was added diisopropylamine (2.7 ml, 19.5 mmol, 3 eq), dry THF (50 mL) and 3-(2,4-Bis-methoxymethoxy-phenyl)-7-methoxymethoxy-4-methyl-chromen-2-one (8.1 mL, 16.25 mmol, 2.5 eq.) at  $-78^\circ C$ . After 30 minutes, to this solution was added  
25 drop-wise, a solution of 3-(2,4-bis-methoxymethoxy-phenyl)-7-

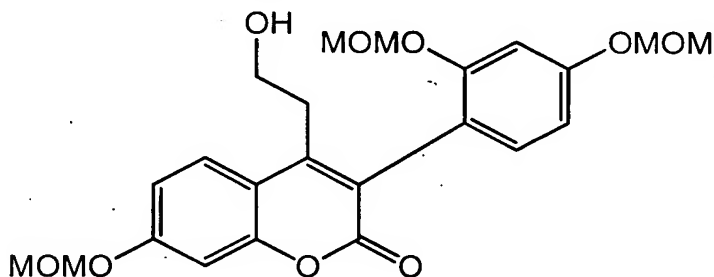
methoxymethoxy-4-methyl-chromen-2-one (2.7 g, 6.5 mmol, 1 eq.) in dry THF (13 mL). The solution was warmed to  $-10^{\circ}\text{C}$  and stirred at this temperature for 30 minutes. Phenyl formate (3.6 ml, 33 mmol, 5 eq) was then added slowly into the reaction mixture. The reaction mixture was then stirred for 30 mins;  
 5 quenched with saturated aqueous  $\text{NH}_4\text{Cl}$ , extracted with ethyl acetate and then concentrated to yield the title product as a crude solid which was purified by flash chromatography eluting with 30% ethyl acetate in hexane to yield the title product as a solid.

MS: 443.0, M-H;

10  $^1\text{H-NMR}$  (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  (ppm) 9.7 (s, 1H), 6.8-7.4 (m, 6H), 5.25 (s, 2H), 5.2 (s, 2H), 5.1 (s, 2H), 3.7-3.9 (m, 2H), 3.49 (s, 3H), 3.5 (s, 3H), 3.4 (s, 3H).

### EXAMPLE 71

15 3-(2,4-Bis-methoxymethoxy-phenyl)-4-(2-hydroxy-ethyl)-7-methoxymethoxy-chromen-2-one



Sodium borohydride (17 mg, 0.45 mmol, 0.5 eq.) was dissolved in ethanol (5 mL), then added into the solution of [3-(2,4-Bis-methoxymethoxy-phenyl)-7-methoxymethoxy-2-oxo-2H-chromen-4-yl]-acetaldehyde (400 mg, 0.90 mmol, 1 eq.) ethanol (10 mL) at  $-10^{\circ}\text{C}$  and the reaction mixture was stirred for 30 minutes. The solvent was evaporated and the resulting residue was dissolved in ethyl acetate (100 mL) and washed twice with brine. The organic layer was dried over anhydrous sodium sulfate then concentrated to  
 20 yield the crude product which was purified by flash chromatography eluted with 50% ethyl acetate to yield the title compound 3-(2,4-Bis-methoxymethoxy-phenyl)-4-(2-hydroxy-ethyl)-7-methoxymethoxy-chromen-2-one as a solid.  
 25

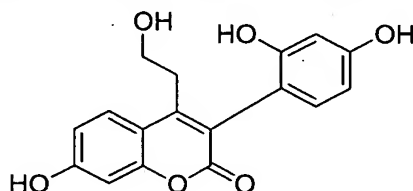
MS: 447.1, M+H; 469.1, M+Na; 445.1 M-H

<sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>): δ (ppm) 6.8-7.7 (m, 6H), 5.3 (s, 2H), 5.25 (s, 2H), 5.2 (s, 2H), 3.8 (m, 2H), 3.51 (s, 3H), 3.50 (s, 3H), 3.4 (s, 3H), 3.0 (m, 2H), 1.75 (t, 1H).

5

### EXAMPLE 72

#### 3-(2,4-Dihydroxy-phenyl)-7-hydroxy-4-(2-hydroxy-ethyl)-chromen-2-on



Into a flask purged with nitrogen was added 3-(2,4-Bis-methoxymethoxy-phenyl)-4-(2-hydroxy-ethyl)-7-methoxymethoxy-chromen-2-one (200 mg) and 1N HCl (10 mL) in 1:1 isopropanol:THF. The reaction mixture was stirred overnight, then diluted with ethyl acetate (200 mL) and washed three times with brine. The organic layer was dried over anhydrous sodium sulfate and then concentrated. The residue was purified by flash chromatography eluted with 10% methanol in dichloromethane to yield 3-(2,4-dihydroxy-phenyl)-7-hydroxy-4-(2-hydroxy-ethyl)-chromen-2-one as a solid.

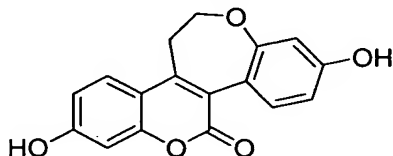
MS: 313.0 M-H; 315.1 M+H, 337.0, min;

<sup>1</sup>H-NMR (300 MHz, CD<sub>3</sub>OD): δ (ppm) 6.3-7.8 (m, 6H), 3.65 (m, 2H), 2.9 (m, 2H).

20

### EXAMPLE 73

#### 2,8-Dihydroxy-11,12-dihydro-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-one Compound #56



25

Into a dry clean flask purged with nitrogen was added 3-(2,4-Dihydroxy-phenyl)-7-hydroxy-4-(2-hydroxy-ethyl)-chromen-2-on (50 mg, 0.16 mmol, 1 eq.) triphenylphosphine (176 mg, 0.67 mmol, 4.2 eq.), 4 Å molecular sieve (50 mg)

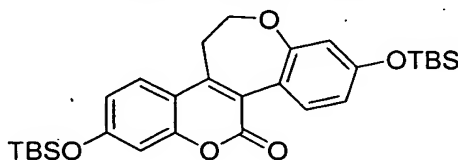
and dry THF (10 mL) and the reaction mixture was stirred for 30 minutes. To the reaction mixture was then added DEAD (0.11 mL, 0.67 mmol, 4.2 eq.) and the reaction stirred at room temperature for 1 hour. The insoluble material was filtered and the filtrate was concentrated. The residue was purified by flash chromatography eluted with 2% methanol in dichloromethane to yield the title product as a solid.

MS: 295.0 M-H; 297 M+H; 319 m/z;

$^1\text{H-NMR}$  (300 MHz, THF- $d_8$ ):  $\delta$  (ppm) 6.5-7.8 (m, 6H), 4.6 (t, 2H), 3.0 (t, 2H).

#### EXAMPLE 74

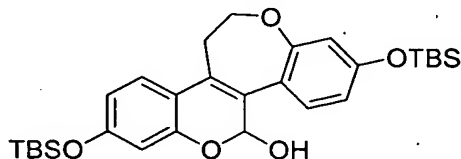
##### 2,8-Dihydroxy-11,12-dihydro-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-one



2,8-Dihydroxy-11,12-dihydro-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-one (30 mg) was dissolved in THF (1 mL). To the reaction mixture was then added triethylamine (0.2 mL) and 1M TBSCl (0.2 mL) in dichloromethane and the reaction mixture stirred at room temperature for 30 minutes. The reaction mixture was diluted with ethyl acetate (20 mL) and then washed twice with brine. The organic layer was dried over anhydrous sodium sulfate and concentrated. The crude product was purified by flash chromatography eluted with 100:10:2 hexane/dichloromethane/ethyl acetate, to yield 2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-one as a solid.

MS  $m/z$  525( $M+H^+$ ), 547( $M+Na^+$ )

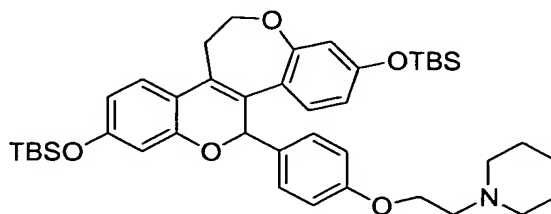
$^1\text{H NMR}$ ( $\text{CDCl}_3$ , 300 MHz)  $\delta$ (ppm): 6.6-7.8 (m, 6H), 4.6 (t, 2H), 3.0 (t, 2H). 1.1(2s, 18H), 10.2- -0.1(2s, 12H)

**EXAMPLE 75****2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol**

- 5        2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-one (35 mg, 0.066 mmol) was dissolved in toluene (5 mL) and the resulting solution was cooled to  $-78^{\circ}\text{C}$ . A solution of Dibal-H solution (70  $\mu\text{L}$ , 1.5 M solution in toluene) was then added to above reaction mix at  $-78^{\circ}\text{C}$ . The reaction mixture was stirred at  $-78^{\circ}\text{C}$  for 3h.
- 10    To the reaction mixture was then added methanol (0.5 mL), and then Rochelle solution (2 ml, 1M solution). The reaction mixture was gradually warmed to room temperature. The reaction mix was diluted with  $\text{CH}_2\text{Cl}_2$  (30 mL), the organic layer was separated and dried over  $\text{Na}_2\text{SO}_4$ . The solution was filtered and evaporated to yield a crude product that was purified on  $\text{SiO}_2$  to yield the
- 15    title compound as a solid.

MS  $m/z$  527( $\text{M}+\text{H}^+$ ), 550( $\text{M}+\text{Na}^+$ )

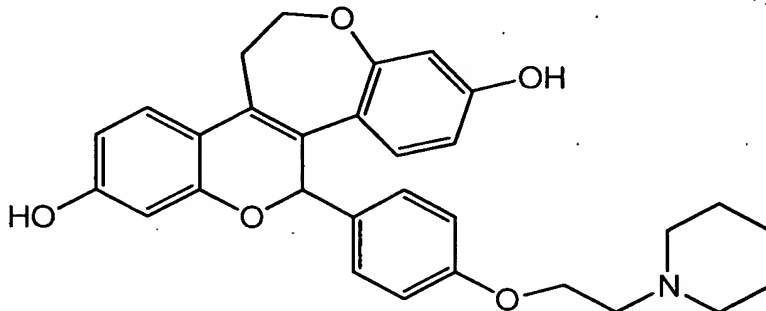
- $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.15 (1H, d,  $J = 8.4$  Hz), 6.96 (1H,  $J = 8.4$  Hz), 6.59 (1H, d,  $J = 2.24$  Hz), 6.54 (1H, d, d,  $J = 2.31, 11.62$  Hz), 6.46 (1H, d, d,  $J = 2.31, 8.35$  Hz), 6.41 (1H, d,  $J = 2.31$  Hz), 6.11 (1H, d,  $J = 8.1$  Hz), 4.6
- 20    (2H, m), 3.0 (2H, m), 0.98 (18H, s), 0.22 (6H, s), 0.21 (6H, s)

**EXAMPLE 76****1-(2-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl]-phenoxy}-ethyl)-piperidine**

1-[2-(4-Iodo-phenoxy)-ethyl]-piperidine (150 mg, 0.453 mmol) was dissolved in THF and cooled to  $-78^{\circ}\text{C}$ . To the reaction mixture was then added n-butyl lithium (2M solution in pentane, 226  $\mu\text{l}$ ), slowly over 5 min. The reaction mixture was stirred for 1h at  $-78^{\circ}\text{C}$ . In a separate flask, 2,8-bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol (28 mg, 0.053 mmol) was dissolved in THF (1 mL) and added to the reaction mixture containing the 1-[2-(4-Iodo-phenoxy)-ethyl]-piperidine and n-butyl lithium, slowly over 5 min. The reaction mixture was stirred for additional 1hr. The reaction mixture was quenched by MeOH (0.5 mL), treated with a saturated solution of ammonium chloride (30 mL) and then diluted with diethyl ether (25 mL). The organic layer was separated and washed with brine (15 mL). The organic layer was dried over anhydrous  $\text{Na}_2\text{SO}_4$ , filtered and the solvent evaporated to yield a crude oil. The crude oil was diluted with toluene (30 mL) and 1N HCl (6.0 mL) and then stirred for 30 min at room temperature. The reaction mixture was diluted with EtOAc (20 mL) and the organic layer was washed twice with water (20 mL) and with a saturated solution of  $\text{NaHCO}_3$  (10 mL). The organic layer was separated, dried over anhydrous  $\text{Na}_2\text{SO}_4$ , filtered and evaporated to yield 1-(2-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl]-phenoxy}-ethyl)-piperidine as an oil.

MS  $m/z$  714( $\text{M}+\text{H}^+$ )

$^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$ : 7.46 (2H, d,  $J = 8.7$  Hz), 6.87 (1H, d,  $J = 8.30$  Hz), 6.79 (2H, d,  $J = 1.91, 6.82$  Hz), 6.70 (1H, d,  $J = 8.42$  Hz), 6.39 (2H, m), 6.29 (2H, m), 6.14 (1H, s), 5.30 (1H, d,  $J = 13.90$  Hz), 5.10 (1H, d,  $J = 13.90$  Hz), 4.6 (m, 2H), 4.04 (2H, m), 3.0 (m, 2H), 2.48 (2H, t,  $J = 6.0$  Hz), 2.48 (4H, m), 1.58 (4H, m), 1.43 (2H, m), 0.95 (9H, s), 0.93 (9H, s), 0.18 (6H, s), 0.16 (6H, s).

**EXAMPLE 77****5-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol Compound #55**

5 To the solution of 1-(2-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl]-phenoxy}-ethyl)-piperidine (1.6 mg, 0.0022 mmol), prepared as in Example 76, in THF (0.1 mL) was added TBAF (10  $\mu$ l, 1M solution in THF, 0.010 mmol) at -10°C. The solution changed to slight yellow. The solution was stirred at -10°C for 30

10 mins. To the solution was then added saturated aqueous  $\text{NH}_4\text{Cl}$  (0.1 mL) to quench the reaction. The reaction mixture was extracted by ethyl acetate (100 ml), the organic solvent was dried over anhydrous  $\text{Na}_2\text{SO}_4$ , the organic solvent was filtered and concentrated in vacuum to yield an oil which was purified by reverse phase HPLC to yield the title compound.

15  $^1\text{H}$ NMR (300 MHz,  $\text{CD}_3\text{OD}$ ): 7.4(d, J = 10 Hz, 2H), 7.15 (d, J =10 Hz, 1H), 7.0 (d, J = 10 Hz, 1H), 6.85 (d, J = 10 Hz, 2H), 6.5 (m, 2H), 6.35 (dd, 1H), 6.15 (d, J = 3 Hz, 1H), 6.05 (s, 1H), 4.6 (m, 2H), 4.3 (t, J = 5 Hz, 2H), 3.55 (d, J = 12 Hz, 2H), 3.45 (t, J = 5 Hz, 2H), 3.3 (m, 2H), 3.0 (m, 2 H), 2.8 (m, 2H), 1.9 (m, 2H), 1.75 (m, 2H);

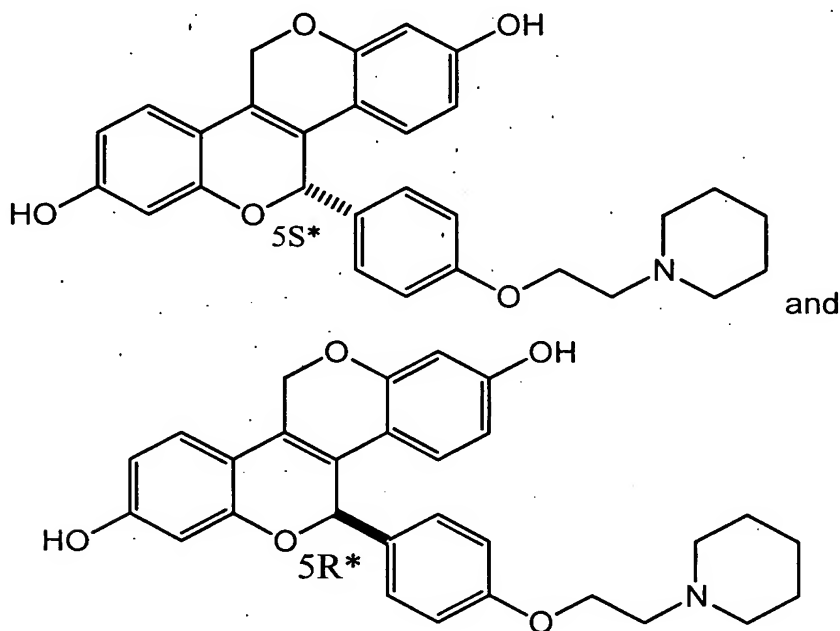
20 MS(Cl) m/z: 485(M+H $^+$ ).



**EXAMPLE 78**

**5R<sup>\*</sup>-(-)-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromene-2,8-diol and 5S<sup>\*</sup>-(+)-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromene-2,8-diol Compounds #14, #15**

5



The racemic mixture of 5-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromene-2,8-diol (50 mg) was loaded onto a ChiralPak AD chiral HPLC column (21 mm I.D. x 250mm L) and eluted with 50% methanol in isopropyl alcohol at the 4 mL/min flow rate. Two peaks were collected separately and were removed under vacuum to yield: 5R<sup>\*</sup>-(-)-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromene-2,8-diol as peak one.

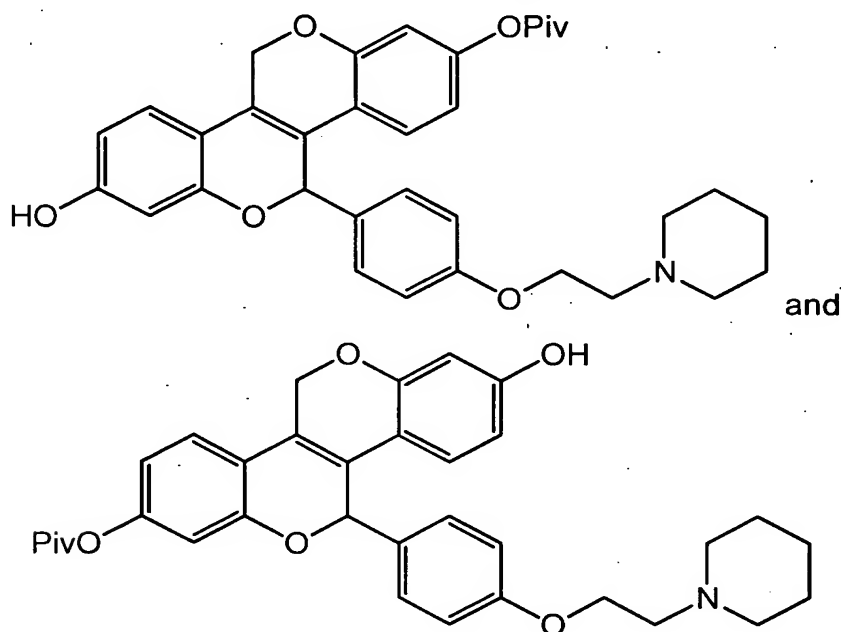
MS(Cl) m/z 472(M+H<sup>+</sup>)  
and 5S<sup>\*</sup>-(+)-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromene-2,8-diol as peak two.

MS(Cl) m/z 472(M+H<sup>+</sup>)

20

**EXAMPLE 79**

**2,2-Dimethyl-propionic acid 8-hydroxy-11-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester and 2,2-Dimethyl-propionic acid 8-hydroxy-5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester Compounds #51, #52**



TBAF (1 M in THF, 850  $\mu$ L, 0.85 mmol, 3 eq.) was added drop-wise into a solution of 1-(2-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-phenoxy}-ethyl)-piperidine (200mg, 0.285 mmol) in THF (10 mL) at  $-10^{\circ}\text{C}$ . The reaction mixture was stirred for 15 minutes. To the reaction mixture was then added 2,2-dimethylpropionic acid chloride (714  $\mu$ L, 0.285 mmol, 1 eq). The reaction mixture was diluted with ethyl acetate and washed with 5% sodium bicarbonate and then with brine. The organic layer was dried over anhydrous  $\text{Na}_2\text{SO}_4$ , and concentrated to yield a crude oil, which was purified by HPLC (using Luna C18 column, 1% TFA in acetonitrile (ACN) and 1% TFA in  $\text{H}_2\text{O}$  as gradient solvent system). Two peak were collected separately and evaporated to dryness in vacuum to yield 2,2-Dimethyl-propionic acid 8-hydroxy-11-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester as peak one

MS(Cl) m/z: 556( $\text{M}=\text{H}^+$ )

and 2,2-Dimethyl-propionic acid 8-hydroxy-5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester as peak two.

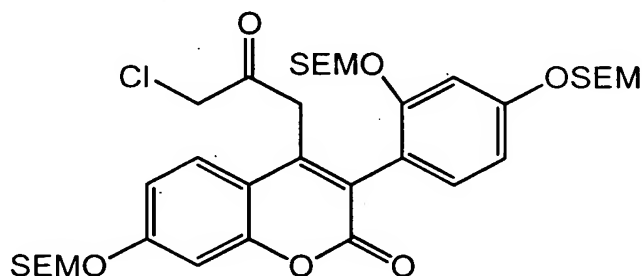
MS(Cl) m/z: 556(M=H<sup>+</sup>)

<sup>1</sup>HNMR (300 MHz, CDCl<sub>3</sub>): δ 7.42 (2H, d, J = 8.7 Hz), 7.03 (1H, d, J = 8.4 Hz), 6.83 – 6.79 (3H, m), 6.64 (1H, d, d, J = 2.3, 8.5 Hz), 6.64 (1H, d, J = 2.3 Hz), 6.54 – 6.49 (2H, m), 6.51 (1H, s), 5.47 (1H, d, J = 14 Hz), 5.17 (1H, d, J = 14 Hz), 4.05 (2H, t, J = 6.0 Hz), 2.74 – 2.49 (5H, brs), 1.59 (4H, m), 1.37 (2H, m), 1.32 (9H, s)

10

### Example 80

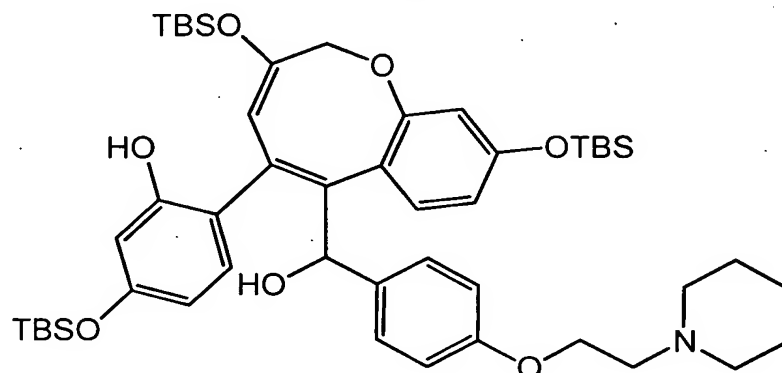
**3-[2,4-Bis-(2-trimethylsilyl-ethoxymethoxy)-phenyl]-4-(3-chloro-2-oxo-propyl)-7-(2-trimethylsilyl-ethoxymethoxy)-chromen-2-one**



At room temperature, 3-[2,4-Bis-(2-trimethylsilyl-ethoxymethoxy)-phenyl]-4-methyl-7-(2-trimethylsilyl-ethoxymethoxy)-chromen-2-one (1.6 g, 2.37 mmol) in THF (10 mL) was added LiHMDS (2.9 mL, 2.84 mmol) slowly. The reaction mixture was stirred for 10 min and then added into chloroacetyl chloride (0.28 mL, 1.5 equiv.) in THF (20 mL) at -20°C. The reaction mixture was maintained at -20°C for 1 hour, then diluted with diethyl ether (200 mL), washed with aqueous NH<sub>4</sub>Cl (100ml), brine and organic layer was dried over anhydrous MgSO<sub>4</sub>. The resulting product was then concentration by vacuum to dryness and purified by silica gel column chromatography to yield the title compound as a colorless oil.

<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ -0.1 ~ 0.2 (m, 27H), 3.52 ~ 4.12 (m, 10H), 5.08 (s, 2H), 5.26 (s, 2H), 5.27 (s, 2H), 6.74 (m, 1H), 6.95 ~ 7.18 (m, 4H), 7.31 (m, 1H)

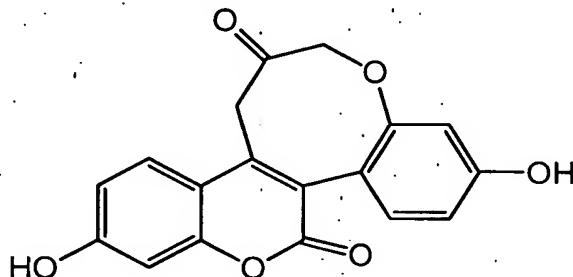
MS (m/z): MNa<sup>+</sup> (773), MH<sup>+</sup> (749).

**Example 81****4-(3-Chloro-2-oxo-propyl)-3-(2,4-dihydroxy-phenyl)-7-hydroxy-chromen-2-one**

5            3-[2,4-Bis-(2-trimethylsilyl-ethoxymethoxy)-phenyl]-4-(3-chloro-2-oxo-propyl)-7-(2-trimethylsilyl-ethoxymethoxy)-chromen-2-one (0.846 g, 1.13 mmol) in HCl (1N, 40 mL 1:1 THF : iPrOH) was stirred overnight at 25°C. The reaction mixture was then diluted with ethyl acetate (10 mL) and washed with brine (2 x 30 mL). The aqueous layer was extracted with ethyl acetate (2  
10   x 50 mL). The organic layers were combined, dried, concentrated and purified by silica gel column chromatograph (5% MeOH / DCM) to yield the title compound as white crystals.

<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 3.71 (d, 1H, J = 15.0 Hz), 4.12 (d, 1H, J = 15.0 Hz), 4.52 (m, 2H), 6.25 (m, 2H), 6.75 (m, 3H), 7.5 (m, 1H), 9.35 (s, 1H), 9.45 (s,  
15   1H), 10.50 (s, 1H)

MS (m/z): MH<sup>+</sup> (361), MNa<sup>+</sup> (383), MH<sup>-</sup> (359).

**Example 82****6,12-dihydroxy-[1]benzopyrano[4,3-e][1]benzoxocin-2,9(1*H*,3*H*)-dione****Compound #211**

5            4-(3-Chloro-2-oxo-propyl)-3-(2,4-dihydroxy-phenyl)-7-hydroxy-chromen-2-one (356 mg, 0.86 mmol) was stirred with K<sub>2</sub>CO<sub>3</sub> (356 mg, 2.57 mmol) in a mixture of acetone (40 mL) and MeOH (20 mL) for 2 h at 25 °C. The color of the reaction mixture was observed to be yellow green. Aqueous HCl (2N, 20 mL) was added and the volatile organic solvents removed by

10            evaporation. The residue was washed with water and filtered to yield the title compound as a slightly yellow powder.

<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 2.08 (m, 2H), 2.68 ~2.92 (m, 2H), 4.95 (m, H), 5.02 (m, 1H), 5.62 (d, 1H, J = 9.8 Hz), 5.96 (d, 1H, J = 9.8 Hz), 7.03 (s, 1H), 7.51 (s, 1H)

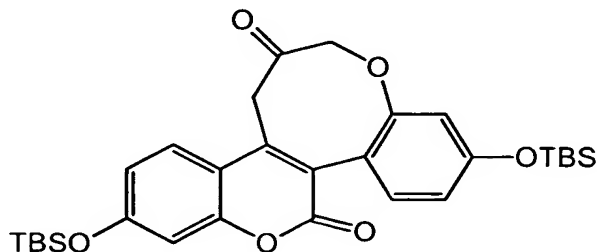
15            MS (m/z): MH<sup>+</sup> (323).

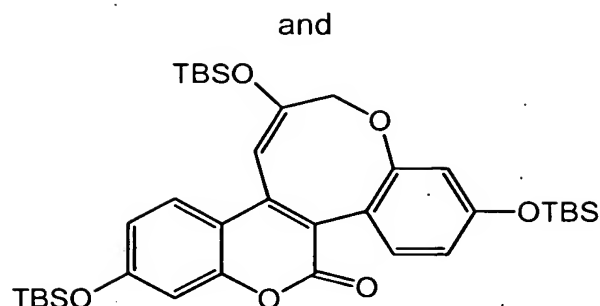
**Example 83**

**6,12-bis[[(1,1-dimethylethyl)dimethylsilyl]oxy]-[1]benzopyrano[4,3-e][1]benzoxocin-2,9(1*H*,3*H*)-dione Compound #212**

20            and

**2,6,12-tris[[(1,1-dimethylethyl)dimethylsilyl]oxy]-2,3-dihydro-[1]benzopyrano[4,3-e][1]benzoxocin-9(1*H*)-one**





6,12-dihydroxy-[1]benzopyrano[4,3-e][1]benzoxocin-2,9(1*H*,3*H*)-dione (prepared as in Example 82 above) (283 mg, 0.87 mmol), TBSCl (1.0 M in DCM, 2.6 mL, 3 equiv.) and TEA (0.36 mL, 3 equiv.) in DCM (10 mL) were stirred at 25°C for 30 min. LC-MS showed the presence of only the 2,8-di(OTBS) product. The reaction mixture was then stirred overnight at 25°C, after which time LC-MS showed the presence of the second 2,8,12-tri(OTBS) substituted product. The reaction mixture was then diluted with diethyl ether (50 mL), washed with water (50 mL), brine and dried over MgSO<sub>4</sub>. The product was purified on silica gel to yield the title compounds as a yellow foam.

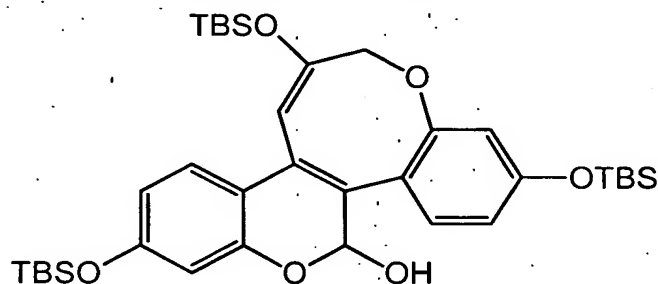
6,12-bis[((1,1-dimethylethyl)dimethylsilyl)oxy]-[1]benzopyrano[4,3-e][1]benzoxocin-2,9(1*H*,3*H*)-dione :

<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 0.10 ~ 0.19 (m, 18H), 0.84, 0.92 (d, 27 H), 4.22 (d, 1H, J = 13.2Hz), 4.79 (d, 1H, J = 13.2 Hz), 5.72 (s, 1H), 6.51 (s, 1H), 6.64 (m, 1H), 6.72 (m, 1H), 6.76 (m, 1H), 7.32 (d, 1H, J = 10.5 Hz), 7.41 (d, 1H, J = 10.5 Hz)

MS (m/z): MH<sup>+</sup> (551)

**Example 84**

**2,6,12-tris[[(1,1-dimethylethyl)dimethylsilyl]oxy]-1,2,3,9-tetrahydro-[1]benzopyrano[4,3-e][1]benzoxocin-9-ol**



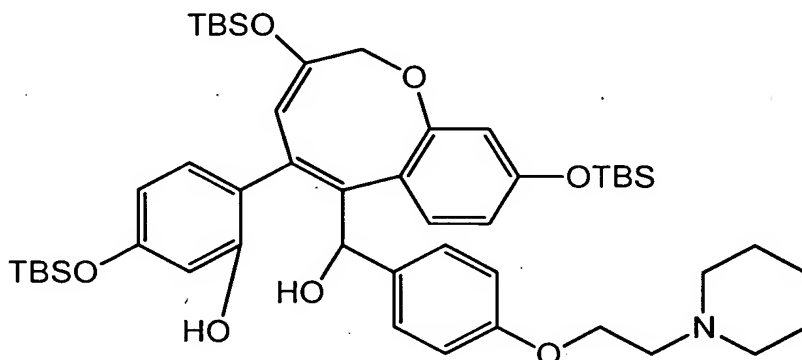
5        2,6,12-tris[[(1,1-dimethylethyl)dimethylsilyl]oxy]-2,3-dihydro-[1]benzopyrano[4,3-e][1]benzoxocin-9(1*H*)-one prepared as in Example 83 above (208 mg, 0.31 mmol) in toluene (5 mL) at -78 °C was reacted with DIBAL (0.21 mL, 1.5 M in toluene, 1 eq.). After 3 hours, another 1 eq. of DIBAL was added to the reaction mixture. The reaction mixture was then  
10        diluted with ethyl acetate (100 mL), washed with Rocelle solution three times and reverse extracted twice with ethyl acetate (25 mL). The organic layers were dried and concentrated. The residue was purified on silica gel (5% ethyl acetate in Hexane) to yield the title compound as a yellow foam.

15        <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 0.10 ~ 0.23 (m, 18H), 0.86 ~ 1.25 (m, 27H), 3.16 (d, 1H, J = 8.8 Hz), 4.25 (d, 1H, J = 14.8 Hz), 5.01 (d, 1H, J = 17.7 Hz), 5.57 (s, 1H), 6.02 (d, 1H, J = 8.0 Hz), 6.53 ~ 6.70 (m, 4H), 7.15 (m, 1H), 7.23 (m, 1H)

MS (m/z): MH<sup>+</sup> (667)

**Example 85**

**2-(3,9-Bis-(tert-butyl-dimethyl-silyloxy)-6-{hydroxy-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-methyl}-2H-benzo[b]oxocin-5-yl)-5-(tert-butyl-dimethyl-silyloxy)-phenol**



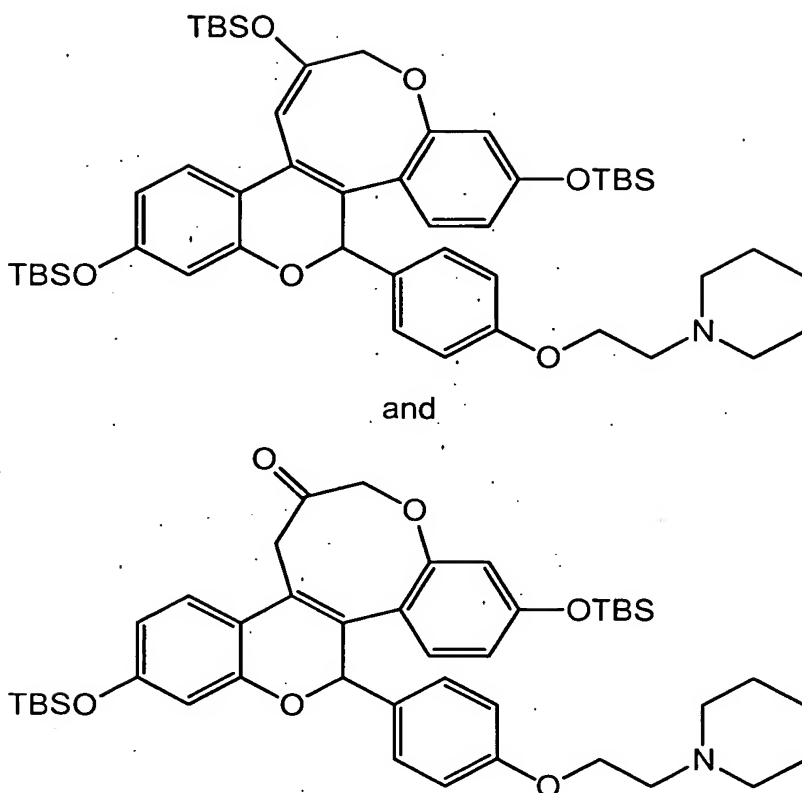
5  
Iodide (634 mg, 1.91 mmol, 5 eq.) in THF (5 mL) at -78 °C was reacted with nBuLi (0.76 mL, 2.5 M in hexanes) for 15 min. The mixture was then added to a solution of 2,6,12-tris[[(1,1-dimethylethyl)dimethylsilyl]oxy]-1,2,3,9-tetrahydro-[1]benzopyrano[4,3-e][1]benzoxocin-9-ol, the compound prepared as in Example 84 above (256 mg, 0.38 mmol) in THF (5 mL) at -78°C and the  
10 resulting reaction mixture stirred for 1 h. The reaction mixture was quenched with MeOH (0.1 mL) and then with aqueous NH<sub>4</sub>Cl. The resulting mixture was extracted with ethyl acetate (200 mL). The organic layers were dried and concentrated and azeotropically distilled with benzene (50 mL) to yield the title  
15 product as a crude oil.

MS (m/z): MH<sup>+</sup> (874), MH<sup>-</sup> (872).

**Example 86**

20 **1-[2-[4-[2,6,12-tris[[(1,1-dimethylethyl)dimethylsilyl]oxy]-3,9-dihydro[1]benzopyrano[4,3-e][1]benzoxocin-9-yl]phenoxy]ethyl]-piperidine**  
**and**  
**6,12-bis[[(1,1-dimethylethyl)dimethylsilyl]oxy]-1,9-dihydro-9-[4-[2-(1-piperidinyl)ethoxy]phenyl]-[1]benzopyrano[4,3-e][1]benzoxocin-2(3H)-**  
25 **one Compound #95**





The crude 2-(3,9-Bis-(tert-butyl-dimethyl-silyloxy)-6-{hydroxy-[4-(2-  
5 piperidin-1-yl-ethoxy)-phenyl]-methyl}-2H-benzo[b]oxocin-5-yl)-5-(tert-butyl-  
dimethyl-silyloxy)-phenol, as in Example 85 (0.38 mmol) in DCM (10 mL) at -  
10°C was mixed with  $\text{BF}_3 \cdot \text{Et}_2\text{O}$  (0.32 mL, 2.47 mol, 6.5 equiv.) for 30 min.  
The resulting reaction mixture was quenched with water (5 mL) and stirred for  
10 min. The reaction mixture was then diluted with ethyl acetate (100 mL),  
washed twice with 5% HCl twice and then twice with brine. The resulting  
residue was dried and concentrated to yield the title compounds as a mixture,  
as an oil.

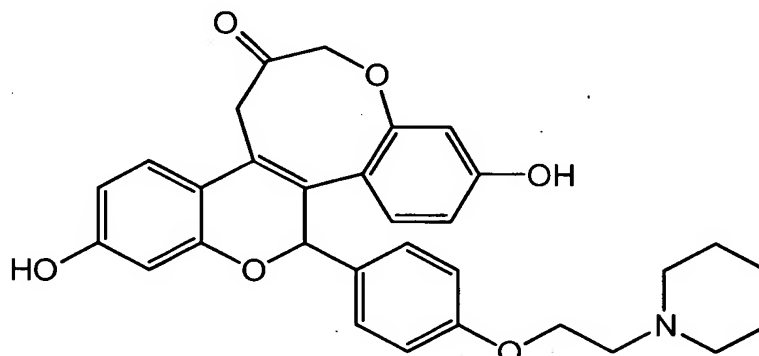
The oil was separated into the following components by flash  
chromatography.

15 1-[2-[4-[2,6,12-tris(((1,1-dimethylethyl)dimethylsilyl)oxy)-3,9-  
dihydro[1]benzopyrano[4,3-e][1]benzoxocin-9-yl]phenoxy]ethyl]-piperidine:

MS (m/z):  $\text{MH}^+$  (856)

6,12-bis(((1,1-dimethylethyl)dimethylsilyl)oxy)-1,9-dihydro-9-[4-[2-(1-  
piperidinyl)ethoxy]phenyl]- [1]benzopyrano[4,3-e][1]benzoxocin-2(3H)-one:

20 MS (m/z):  $\text{MH}^+$  (740)

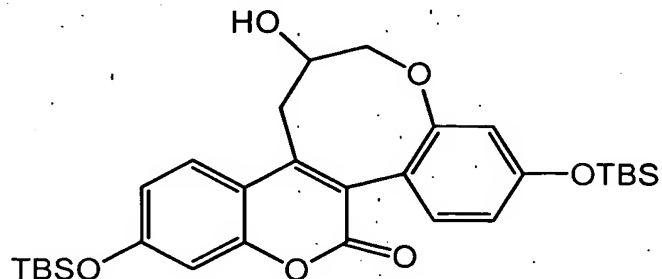
**Example 87****1,9-dihydro-6,12-dihydroxy-9-[4-[2-(1-piperidinyl)ethoxy]phenyl]-[1]benzopyrano[4,3-e][1]benzoxocin-2(3H)-one Compound #96**

5 The crude product mixture, 1-[2-[4-[2,6,12-tris[[[(1,1-dimethylethyl)dimethylsilyl]oxy]-3,9-dihydro[1]benzopyrano[4,3-e][1]benzoxocin-9-yl]phenoxy]ethyl]-piperidine and 6,12-bis[[[(1,1-dimethylethyl)dimethylsilyl]oxy]-1,9-dihydro-9-[4-[2-(1-

10 piperidinyl)ethoxy]phenyl]-[1]benzopyrano[4,3-e][1]benzoxocin-2(3H)-one, prepared as in Example 86 above (0.38 mmol), was dissolved in THF (4 mL). A pre-made solution of TBAF (1.50 mL, 1.5 mmol, 4.0 eq.) and acetic acid (0.043 mL, 0.76 mmol, 2.0 eq.) in THF was added (2.0 mL) and the reaction mixture was stirred for 14 hours. The reaction mixture was then diluted with

15 ethyl acetate (10 mL) and washed with brine (2 x 30 mL). The aqueous layer was extracted with ethyl acetate (2 x 50 mL). The organic layers were combined, dried, concentrated and purified by silica gel column chromatograph (50-100% Hexanes/Ethyl acetate) to yield the title compound as white powder.

20 MS (m/z):  $MH^+$  (514)

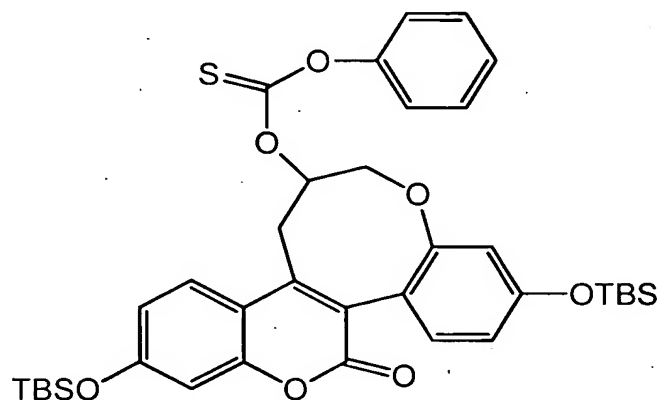
**Example 88****6,12-bis[[(1,1-dimethylethyl)dimethylsilyl]oxy]-2,3-dihydro-2-hydroxy-[1]benzopyrano[4,3-e][1]benzoxocin-9(1*H*)-one Compound #216**

5. A solution of 6,12-bis[[(1,1-dimethylethyl)dimethylsilyl]oxy]-[1]benzopyrano[4,3-e][1]benzoxocin-2,9(1*H*,3*H*)-dione, prepared as in Example 83 (216mg, 0.4 mmol) in ethanol (4mL) and was added to NaBH<sub>4</sub> (7.4 mg, 0.5 eq.) at -10°C. The reaction mixture was maintained at this temperature, with stirring for 2 hours. At that time, additional NaBH<sub>4</sub> (12 mg )
- 10 was added and the reaction mixture stirred for another hour. The reaction mixture was quenched with aqueous NH<sub>4</sub>Cl (5 mL) and then extracted with ethyl acetate (50 mL). The Organic ayers was separated and , dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>, concentrated and purified on silica gel (15% Ethyl acetate in Hexane) to yield the title compound as a solid foam.

15 MS (m/z): MH<sup>+</sup> (554).

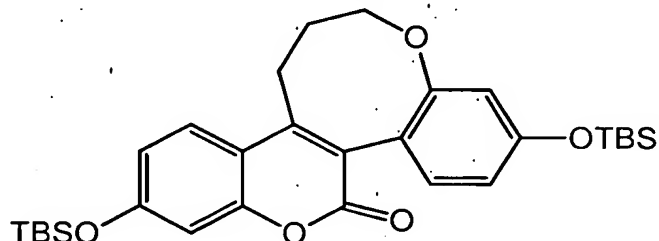
**Example 89**

**O-[6,12-bis[[(1,1-dimethylethyl)dimethylsilyl]oxy]-1,2,3,9-tetrahydro-9-oxo[1]benzopyrano[4,3-e][1]benzoxocin-2-yl] O-phenyl ester carbonothioic acid**



5  
6,12-Bis[[(1,1-dimethylethyl)dimethylsilyl]oxy]-2,3-dihydro-2-hydroxy-[1]benzopyrano[4,3-e][1]benzoxocin-9(1*H*)-one, prepared as in Example 88 above (215 mg, 0.388 mmol) was mixed with thionyl chloride (80.081 mL, 0.582 mmol, 1.5 eq.), pyridine (0.082 mL, 1 mmol, 2.6 eq.) and DMAP (2.4  
10 mg, 0.02 mmol, 5% eq.) in DCM (4 mL) and the reaction mixture stirred at room temperature overnight. The reaction mixture was then diluted with wthyl acetate (50 mL), washed twice with saturated CuSO<sub>4</sub> and then washed twice with brine. The organic layer was dried over anhydrous sodium sulphate and concentrated under reduced pressure. The resulting oil was purified by flash  
15 column (5% ethyl acetate / hexane) to yield the title compound as a colorless foam solid.

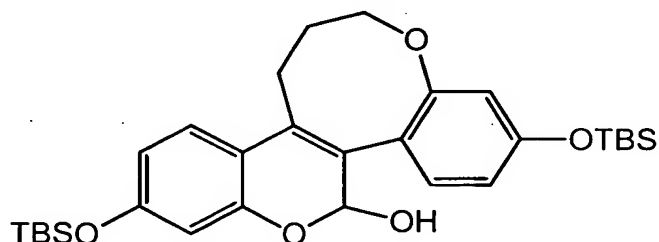
MS (m/z): MH<sup>+</sup> (691), MNa<sup>+</sup> (713).

**Example 90****6,12-bis[[[(1,1-dimethylethyl)dimethylsilyl]oxy]-2,3-dihydro-[1]benzopyrano[4,3-e][1]benzoxocin-9(1*H*)-one Compound #214**

- 5 O-[6,12-bis[[[(1,1-dimethylethyl)dimethylsilyl]oxy]-1,2,3,9-tetrahydro-9-oxo[1]benzopyrano[4,3-e][1]benzoxocin-2-yl] O-phenyl ester carbonothioic acid, prepared as in Example 89 above (236 mg, 0.34 mmol), AIBN (2.8 mg, 0.05 eq.) and  $n\text{Bu}_3\text{SnH}$  (0.137 mL, 1.5 eq.) in toluene (4 mL) were degassed for 5 min by  $\text{N}_2$ , heated to  $80^\circ\text{C}$  and stirred overnight. The reaction mixture
- 10 was then diluted with ethyl acetate (50 mL) and washed with aqueous  $\text{CuSO}_4$  and brine. The organic layer was concentration and purified by silica gel to yield the title compound as white crystals.

MS (m/z):  $\text{MH}^+$  (539).

15

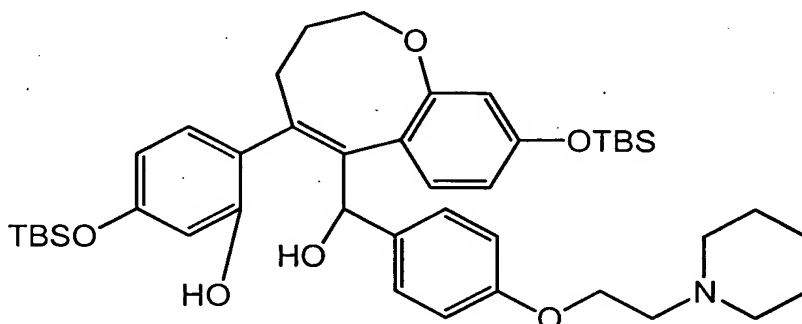
**Example 91****6,12-bis[[[(1,1-dimethylethyl)dimethylsilyl]oxy]-1,2,3,9-tetrahydro-[1]benzopyrano[4,3-e][1]benzoxocin-9-ol Compound #94**

- The compound prepared as in Example 90 above (227 mg, 0.42 mmol)
- 20 was reduced according to the procedure described in Example 84, to yield the title compound as a white solid.

MS (m/z):  $\text{MNa}^+$  (563),  $\text{MH}^+$  (539).

**Example 92**

**5-(tert-Butyl-dimethyl-silyloxy)-2-(9-(tert-butyl-dimethyl-silyloxy)-6-{hydroxy-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-methyl}-3,4-dihydro-2H-benzo[b]oxocin-5-yl)-phenol Compound #291**

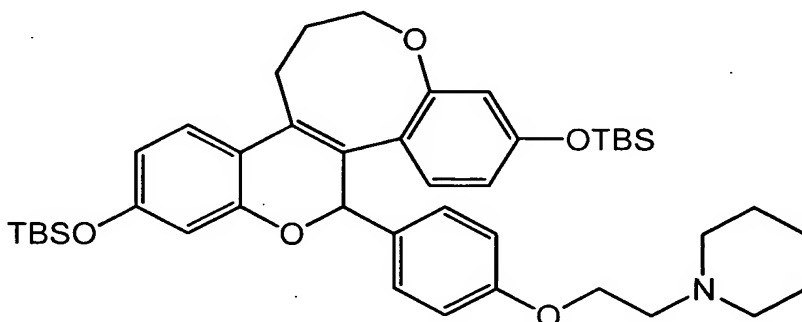


The title compound was prepared according to the procedure described in Example 85 above, substituting 6,12-bis[[(1,1-dimethylethyl)dimethylsilyl]oxy]-1,2,3,9-tetrahydro-[1]benzopyrano[4,3-e][1]benzoxocin-9-ol for 2,6,12-tris[[(1,1-dimethylethyl)dimethylsilyl]oxy]-1,2,3,9-tetrahydro-[1]benzopyrano[4,3-e][1]benzoxocin-9-ol to yield the title compound as a yellow oil.

MS (m/z):  $MH^+$  (746).

**Example 93**

**1-[2-[4-[6,12-bis[[(1,1-dimethylethyl)dimethylsilyl]oxy]-1,2,3,9-tetrahydro[1]benzopyrano[4,3-e][1]benzoxocin-9-yl]phenoxy]ethyl]-piperidine Compound #282**



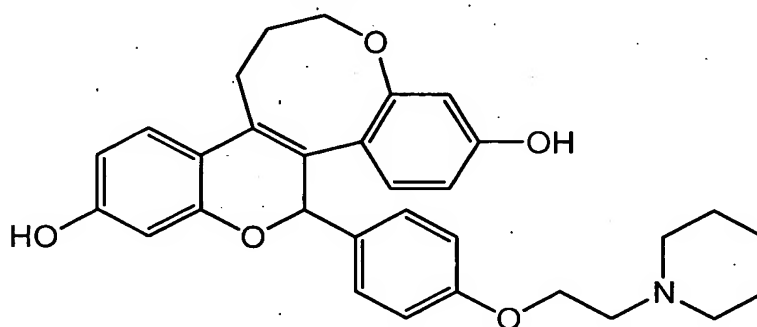
The title compound was prepared according to the procedure described in Example 86 above, substituting 5-(tert-Butyl-dimethyl-silyloxy)-2-(9-(tert-butyl-dimethyl-silyloxy)-6-{hydroxy-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-

methyl}-3,4-dihydro-2H-benzo[b]oxocin-5-yl)-phenol for 2-(3,9-Bis-(tert-butyl-dimethyl-silyloxy)-6-{hydroxy-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-methyl}-2H-benzo[b]oxocin-5-yl)-5-(tert-butyl-dimethyl-silyloxy)-phenol, to yield the title compound as a foam.

5 MS (m/z):  $MH^+$  (728).

#### Example 94

#### 1,2,3,9-tetrahydro-9-[4-[2-(1-piperidinyl)ethoxy]phenyl]- [1]benzopyrano[4,3-e][1]benzoxocin-6,12-diol Compound #97



10

The title compound was prepared according to the procedure described in Example 87 above, substituting 1-[2-[4-[6,12-bis[[[(1,1-dimethylethyl)dimethylsilyl]oxy]-1,2,3,9-tetrahydro[1]benzopyrano[4,3-e][1]benzoxocin-9-yl]phenoxy]ethyl]-piperidine for the crude product mixture to yield the title compound as a pink solid.

15

MS (m/z):  $MH^+$  (500).

The racemic 1,2,3,9-tetrahydro-9-[4-[2-(1-piperidinyl)ethoxy]phenyl]-[1]benzopyrano[4,3-e][1]benzoxocin-6,12-diol (1.0 g) was loaded onto a ChiralPak AS chiral HPLC column (5 cm I.D. X 50 cm L) and eluted with 20% MeOH in IPA at the 90 mL/min flow rate. The two peaks were removed under vacuum to yield the two enantiomers as follows:

20

Peak 2: 1,2,3,9-tetrahydro-9- $R^*$ -(-)-[4-[2-(1-piperidinyl)ethoxy]phenyl]-[1]benzopyrano[4,3-e][1]benzoxocin-6,12-diol

25

$[\alpha] = -57^\circ$ , ( $c = 0.302$ , MeOH)

$^1\text{H}$  NMR ( $\text{CD}_3\text{OD}$ )  $\delta$  1.49 (broad s, 2H), 1.69 (broad s, 4H), 1.91 (broad m, 2H), 2.08 (broad m, 2H), 2.71 (broad m, 4H), 2.92 (broad m, 2H), 3.74 (broad s, 1H), 4.12 (broad m, 2H), 4.56 (broad s, 1H), 5.95 (s, 1H), 6.08 ~ 7.65 (m, 10H)

5 MS (m/z):  $\text{MH}^+$  (500)

Peak 1: 1,2,3,9-tetrahydro-9-S\*-(+)-[4-[2-(1-piperidinyl)ethoxy]phenyl]-[1]benzopyrano[4,3-e][1]benzoxocin-6,12-diol

$[\alpha] = +66^\circ$ , ( $c = 0.402$ , MeOH)

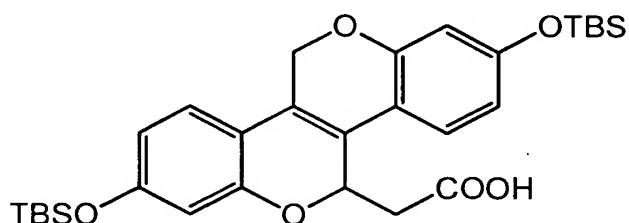
10  $^1\text{H}$  NMR ( $\text{CD}_3\text{OD}$ )  $\delta$  1.49 (broad s, 2H), 1.69 (broad s, 4H), 1.91 (broad m, 2H), 2.08 (broad m, 2H), 2.71 (broad m, 4H), 2.92 (broad m, 2H), 3.74 (broad s, 1H), 4.12 (broad m, 2H), 4.56 (broad s, 1H), 5.95 (s, 1H), 6.08 ~ 7.65 (m, 10H)

MS (m/z):  $\text{MH}^+$  (500)

15

### Example 95

**[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-acetic acid Compound #98**



20 To a solution of 2,8-bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-ol (prepared as in Example 24) (2.87g, 5.6 mmol) in DCM (50 mL) was added  $\text{BF}_3 \cdot \text{etherate}$  (1.42 mL, 11.2 mmol). The reaction mixture was then stirred and observed to turn dark red. After 20 min, 1,1-bis-trimethylsilyloxy-ethene (2mL, 8.4 mmol, 1.5 eq.) was added slowly. After 15 min another portion of 1,1-bis-trimethylsilyloxy-ethene (1g) was added and the solution turned yellow in 10 min. The reaction mixture was diluted with ethyl acetate (200 mL) and then washed with aqueous  $\text{NH}_4\text{Cl}$  solution and brine. Flash chromatograph (20% Ethyl acetate/hexanes) yielded the title compound as a yellow solid.

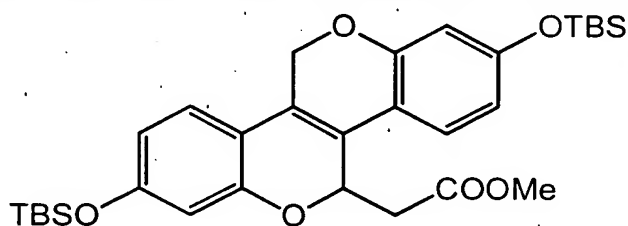


$^1\text{H}$  NMR ( $\text{CDCl}_3$ ) 0.10 (s, 12H), 0.72 (s, 18H), 2.31 (d, 1H,  $J = 11.7$  Hz), 2.68 (m, 1H), 4.69 (d, 1H,  $J = 13.6$  Hz), 4.98 (d, 1H,  $J = 13.6$  Hz), 5.60 (d, 1H,  $J = 11.8$  Hz), 6.18 ~ 6.26 (m, 3H), 6.62 (d, 1H,  $J = 7.8$  Hz), 6.72 (d, 1H,  $J = 7.8$  Hz)

5 MS (m/z):  $\text{MH}^+$  (555),  $\text{MNa}^+$  (577),  $\text{MH}^-$  (553).

### Example 96

**[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-acetic acid methyl ester Compound #101**



10

At room temperature, to a solution of [2,8-Bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-acetic acid, the compound prepared as in Example 95 above (56mg, 0.10 mmol) in benzene (0.7 mL) and MeOH (0.2 mL) was added to  $\text{TMSCHN}_2$  (0.075 mL, 2.0 M in hexanes) and the reaction mixture stirred for 15 min. The solvent was removed and the residue purified by flash chromatograph yielded the title compound as a yellow oil.

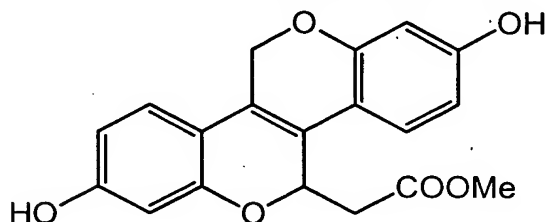
15

$^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  0.08 (s, 12H), 0.78 (s, 18H), 2.26 (d, 1H,  $J = 15.5$  Hz), 3.51 (s, 3H), 4.69 (d, 1H,  $J = 13.8$  Hz), 4.98 (d, 1H,  $J = 13.8$  Hz), 5.56 (d, 1H,  $J = 10.5$  Hz), 6.17 ~ 6.24 (m, 4H), 6.63 (d, 1H,  $J = 6.6$  Hz), 6.74 (d, 1H,  $J = 6.6$  Hz)

20

MS (m/z):  $\text{MH}^+$  (569),  $\text{MNa}^+$  (591),  $\text{MH}^-$  (567).

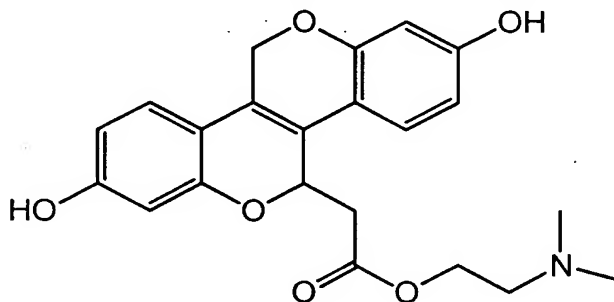
25

**Example 97****(2,8-Dihydroxy-5,11-dihydro-chromeno[4,3-c]chromen-5-yl)-acetic acid methyl ester Compound #102**

5        Following the same procedure as described in Example 87, [2,8-Bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-acetic acid methyl ester, the compound prepared as in Example 96 was reacted with TBAF to yield the title compound, as a yellow solid.

10         $^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  2.47 (m, 1H), 2.72 (m, 1H), 3.69 (s, 3H), 4.88 (d, 1H,  $J = 14.5$  Hz), 5.27 (d, 1H,  $J = 14.5$  Hz), 5.74 (d, 1H,  $J = 10.5$  Hz), 6.34 (m, 2H), 6.44 (m, 2H), 7.00 (m, 2H)

MS ( $m/z$ ):  $\text{MNa}^+$  (363),  $\text{MH}^-$  (339).

**Example 98****(2,8-Dihydroxy-5,11-dihydro-chromeno[4,3-c]chromen-5-yl)-acetic acid 2-dimethylamino-ethyl ester Compound #104****Step A:**

20        A mixture of [2,8-Bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-acetic acid, the compound prepared as in Example 95 above, (56 mg, 0.1 mmol), 2-dimethylamino-ethanol (30  $\mu\text{L}$ , 27 mg, 3.0 eq.), DIC (14 mg, 18  $\mu\text{L}$ ) and DMAP (12 mg) in DCM (2 mL) was stirred for 13 hours. The reaction mixture was then concentrated to yield [2,8-

Bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-acetic acid 2-dimethylamino-ethyl ester as a crude foam.

Step B:

Following the procedure described in Example 87, crude [2,8-Bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-acetic acid 2-dimethylamino-ethyl ester, the compound prepared in Step A above, was dissolved in THF (1mL) at  $-10^{\circ}\text{C}$  and then treated TBAF to yield the title compound as a yellow solid.

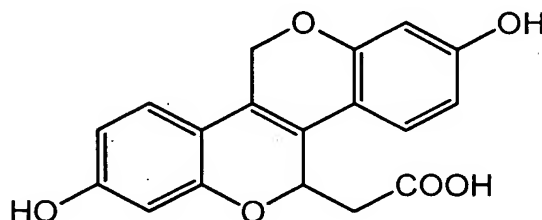
MS (m/z):  $\text{MH}^+$  (398),  $\text{MNa}^+$  (420),  $\text{MH}^-$  (396).

10

**Example 99**

**(2,8-Dihydroxy-5,11-dihydro-chromeno[4,3-c]chromen-5-yl)-acetic acid**

**Compound #107**



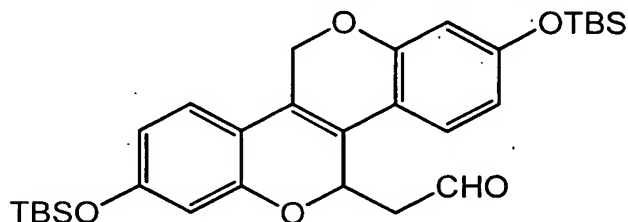
15

Following the procedure described in Example 87, [2,8-Bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-acetic acid, the compound prepared as in Example 95 was (56 mg, 0.1 mmol) reacted with TBAF to yield the title compound as a yellow solid.

$^1\text{H}$  NMR (acetone- $d_6$ )  $\delta$  2.39 (m, 1H), 2.75 (m, 1H), 4.91 (m, 1H), 5.25 (m, 1H), 5.78 (m, 1H), 6.41 (m, 2H), 6.50 (m, 2H), 7.00 (m, 2H)

20

MS (m/z):  $\text{MH}^-$  (325),  $(\text{M} + \text{OAc})^-$  (385).

**Example 100****[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-acetaldehyde**

5 At  $-78^{\circ}\text{C}$ , to a solution of [2,8-Bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-acetic acid methyl ester, the compound prepared as in Example 96 (120 mg, 0.21 mmol) in toluene (2 mL) was added DIBAL (0.28 mL, 1.5 M in toluene, 2 eq.) at  $-78^{\circ}\text{C}$  and stirred for 6 hours at  $-78^{\circ}\text{C}$ . The reaction mixture was then quenched at  $-78^{\circ}\text{C}$  with  
 10 chilled MeOH. HPLC purification of the residue yielded the title compound as a thick oil.

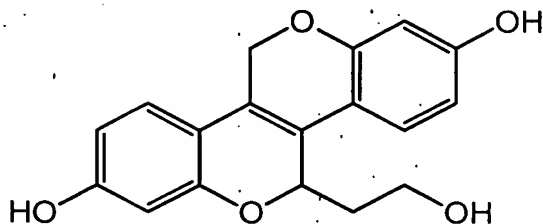
$^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  0.05 (s, 12H), 0.79 (s, 18H), 2.29 (m, 1H), 2.85 (m, 1H), 4.72 (d, 1H,  $J = 13.7$  Hz), 5.08 (d, 1H,  $J = 13.7$  Hz), 5.75 (d, 1H,  $J = 10.0$  Hz), 6.25 (m, 4H), 6.69 (d, 2H,  $J = 9.6$  Hz), 9.61 (s, 2H)

15 MS (m/z):  $\text{MH}^+$  (561),  $\text{MNa}^+$  (593)

A side product, 2-[2,8-bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-ethanol, was also isolated by HPLC as an oil.

$^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  0.05 (s, 12H), 0.79 (s, 18H), 3.56 (m, 1H), 3.71 (m, 1H), 4.72 (d, 1H,  $J = 13.7$  Hz), 4.96 (d, 1H,  $J = 13.7$  Hz), 5.31 (d, 1H), 6.21 ~ 6.78 (m, 6H), 9.61 (s, 2H)

MS (m/z):  $\text{MH}^+$  (563).

**Example 101****5-(2-Hydroxy-ethyl)-5,11-dihydro-chromeno[4,3-c]chromene-2,8-diol****Compound #122**

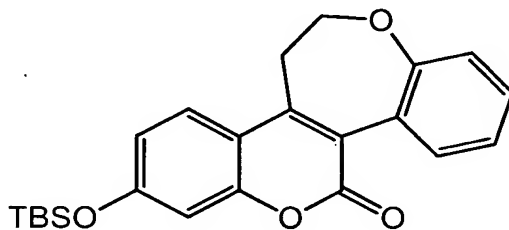
5      Following the procedure described in Example 87, 2-[2,8-bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-ethanol was reacted with TBAF to yield the title compound as a yellow solid.

<sup>1</sup>H NMR (CD<sub>3</sub>OD) δ 0.05 (s, 12H), 0.79 (s, 18H), 3.56 (m, 1H), 3.71 (m, 1H), 4.72 (d, 1H, J = 13.8 Hz), 4.96 (d, 1H, J = 13.8 Hz), 5.31 (d, 1H, J = 9.8 Hz), 6.21 ~ 6.78 (m, 6H), 9.61 (s, 2H)

MS (m/z): MH<sup>+</sup> (313), MH<sup>-</sup> (311)

**Example 102**

**8-(tert-Butyl-dimethyl-silyloxy)-11,12-dihydro-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-one Compound #220**



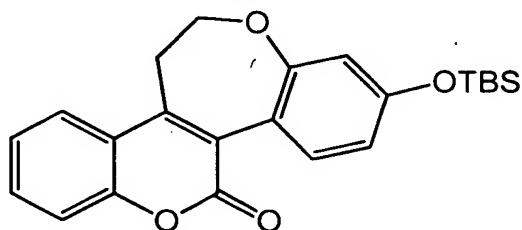
At room temperature, a mixture of 8-Hydroxy-11,12-dihydro-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-one, prepared as in Example 74, (2.0g crude, 7.0 mmol) and TBSCl (5.34 g, 35 mmol), triethylamine (5 mL) in DCM (80 mL) was stirred overnight. The reaction mixture was then washed with water and brine. The organic layers were dried over anhydrous sodium sulphate and concentrated and purified by flash chromatography to yield the title compound as a white solid.

<sup>1</sup>H NMR (CD<sub>3</sub>OD) δ 0.19 (s, 6H), 0.95 (s, 9H), 2.85 (m, 2H), 4.59 (m, 2H), 6.76 ~ 7.72 (m, 6H)

MS (m/z):  $MH^+$  (395),  $MNa^+$  (417),  $2MNa^+$  (811).

**Example 103**

**2-(tert-Butyl-dimethyl-silyloxy)-11,12-dihydro-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-one Compound #221**



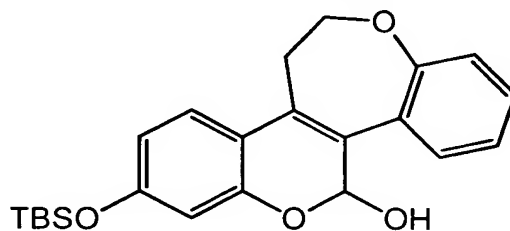
Following the procedure described in Example 102 above, 2-Hydroxy-11,12-dihydro-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-one, prepared as in Example 74 (11.2 g, 40 mmol) was reacted to yield the title compound as a white powder.

$^1H$  NMR ( $CD_3OD$ )  $\delta$  0.19 (s, 6H), 0.95 (s, 9H), 2.85 (m, 2H), 4.60 (m, 2H), 6.55 ~ 7.55 (m, 6H)

MS (m/z):  $MH^+$  (395),  $MNa^+$  (417),  $2MNa^+$  (811),  $MH^-$  (393).

**Example 104**

**8-(tert-Butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol Compound #138**



To a solution of 8-(tert-Butyl-dimethyl-silyloxy)-11,12-dihydro-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-one, the compound prepared as in Example 102 above (3.0 g, 7.56 mmol) at  $-78^\circ C$  was slowly added DIBAL (5.10 mL, 1.5 M in toluene, 1.0 eq). After 3h, the reaction mixture was diluted with ethyl acetate (100 mL), washed with Rocelle solution three times and reverse extracted twice with ethyl acetate (25 mL). The organic layers

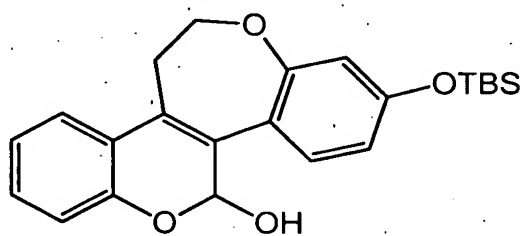
were dried and concentrated. The residue was purified on silica gel (5% ethyl acetate in Hexane) to yield the title compound as a white solid.

$^1\text{H}$  NMR ( $\text{CD}_3\text{OD}$ )  $\delta$  0.21 (s, 6H), 0.98 (s, 9H), 2.72 ~ 3.12 (m, 3H), 4.58 (m, 2H), 6.12 (m, 1H), 6.61 (m, 2H), 7.02 ~ 7.58 (m, 6H).

5 MS (m/z):  $\text{MNa}^+$  (419).

### Example 105

**2-(tert-Butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol Compound #139**



10

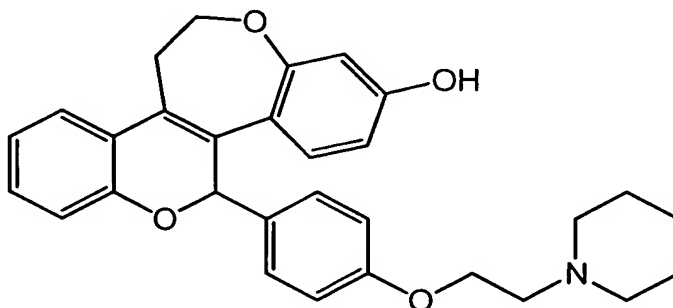
Following the procedure described in Example 104 above, 2-(tert-Butyl-dimethyl-silyloxy)-11,12-dihydro-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-one, the compound prepared as in Example 103 above, (4.0 g, 10.1 mmol) was reacted to yield the title compound as a white solid.

15  $^1\text{H}$  NMR ( $\text{CD}_3\text{OD}$ )  $\delta$  0.26 (s, 6H), 1.05 (s, 9H), 2.85 ~ 3.48 (m, 3H), 4.58 (m, 2H), 6.12 (m, 1H), 6.61 ~ 6.73 (m, 2H), 7.05 ~ 7.42 (m, 6H)

MS (m/z):  $\text{MNa}^+$  (419),  $\text{MH}^+$  (395).

### Example 106

20 **5-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol Compound #140**



Following the procedure described in Examples 76, 2-(tert-Butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol, the compound prepared as in Example 105 above, was reacted with 1-[2-(4-Iodo-phenoxy)-ethyl]-piperidine to yield 2-(8-(tert-Butyl-dimethyl-silyloxy)-5-{hydroxy-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-methyl}-2,3-dihydro-benzo[b]oxepin-4-yl)-phenol as a crude oil. The crude 2-(8-(tert-Butyl-dimethyl-silyloxy)-5-{hydroxy-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-methyl}-2,3-dihydro-benzo[b]oxepin-4-yl)-phenol was then further treated with HCl (12N, 4 eq., 0.67 mL) in toluene (100 mL) to generate yield 1-(2-{4-[2-(tert-Butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl]-phenoxy}-ethyl)-piperidine as a crude oil. The crude 1-(2-{4-[2-(tert-Butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl]-phenoxy}-ethyl)-piperidine was then further treated with HF•Pyridine (70% HF, 30% Pyridine, 0.5 mL) in CH<sub>3</sub>CN (20 mL) at room temperature for 30 min. The reaction mixture was diluted with ethyl acetate:THF (1:1) and then washed with 5% NaHCO<sub>3</sub> and brine. The reaction mixture was dried, concentrated and purified by flash chromatograph eluted with 5% MeOH in DCM to yield the title compound as a slightly yellow solid.

<sup>1</sup>H NMR (Acetone-*d*<sub>6</sub>) δ 1.35 (m, 2H), 1.49 (m, 4H), 2.42 (br s, 4H), 2.64 (m, 2H), 2.71 ~ 2.98 (m, 3H), 3.91 (m, 2H), 4.59 ~ 4.74 (m, 2H), 6.21 (s, 1H), 6.55 ~ 7.45 (m, 11H)

MS (m/z): MH<sup>+</sup> (470)

The racemic 5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol compound 800 mg) was loaded onto a ChiralPak AD chiral HPLC column ( 5 cm I.D. x 50 cm L) and eluted with 100% IPA at the 150 mL/min flow rate. The two peaks were removed under vacuum to yield the enantiomers as follows:



Peak 1: 5R<sup>+</sup>-(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol

<sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 1.36 (m, 6H), 2.28 ~ 2.59 (m, 6H), 2.65 (m, 1H), 2.89 (m, 1H), 3.91 (t, 2H, J = 6.6 Hz), 4.59 (m, 2H), 6.16 ~ 7.38 (m, 12H), 9.65 (s, 1H).

MS (m/z): MH<sup>+</sup> (470); [α]<sub>D</sub> = +39 (c = 0.23, MeOH)

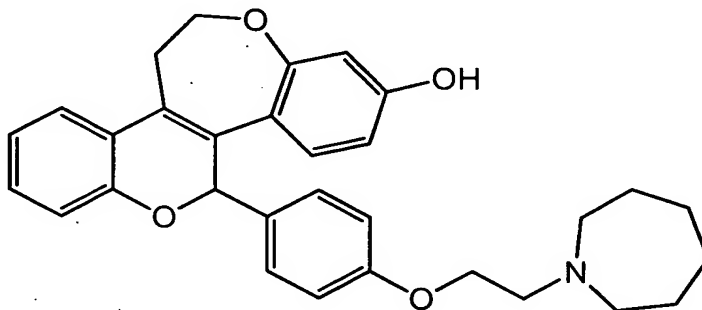
Peak 2: 5S<sup>+</sup>-(-)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol

[α]<sub>D</sub> = -37 (c = 0.43, MeOH)

MS (m/z): MH<sup>+</sup> (470)

### Example 107

**5-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol Compound #141**



Following the procedure described in Example 106 above, 2-(tert-Butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol, the compound prepared as in Example 105 above, (0.8 g, 2.0 mmol) was reacted with 1-[2-(4-Iodo-phenoxy)-ethyl]-azepane to yield the title compound as a yellow solid.

<sup>1</sup>H NMR (Acetone-d<sub>6</sub>) δ 1.54 (m, 8H), 2.58 ~ 2.95 (m, 8H), 3.95 (m, 2H), 4.59 ~ 4.74 (m, 2H), 6.21 (s, 1H), 6.51 ~ 7.45 (m, 11H)

MS (m/z): MH<sup>+</sup> (484).

The racemic 5-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol compound (950 mg) was loaded onto a ChiralPak AD chiral HPLC column (5 cm I.D. x

50 cm L) and eluted with 100% IPA at the 150 mL/min flow rate. The two peaks were removed under vacuum to yield the enantiomers as follows:

Peak 2: 5S\*(-)-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol

5  $[\alpha]_D = -28 (c=0.12, \text{MeOH})$

$^1\text{H}$  NMR ( $\text{DMSO}-d_6$ )  $\delta$  1.51 (broad s, 8H), 2.45 (broad m, 4H), 2.70 (broad m, 2H), 3.22 (broad s, 2H), 3.91 (t, 2H,  $J = 6.6$  Hz), 4.56 (m, 2H), 6.15 (s, 1H), 6.39 ~ 7.36 (m, 11H), 9.67 (s, 1H)

MS (m/z):  $\text{MH}^+$  (484)

10 Peak 1: 5R\*(+)-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol

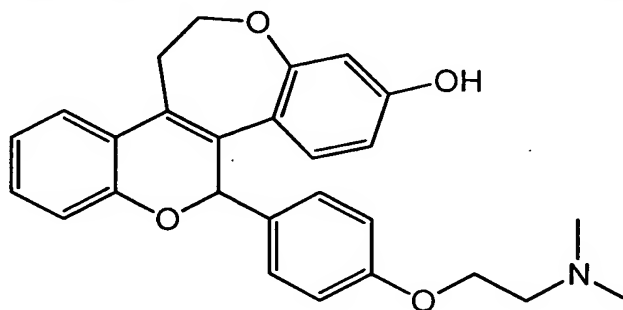
$[\alpha]_D = +38 (c=0.25, \text{MeOH})$ .

$\text{MH}^+$  (484).

15

### Example 108

**5-[4-(2-Dimethylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol Compound #142**



20 Following the procedure described in Example 106, 2-(tert-Butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol, the compound prepared as in Example 105 was reacted in sequence with [2-(4-Iodo-phenoxy)-ethyl]-dimethyl-amine, HCl and then  $\text{HF} \cdot \text{Pyridine}$  to yield the title compound as a yellow solid.

25  $^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  2.28 (s, 6H), 2.72 (m, 2H), 2.82 (m, 2H), 3.95 (m, 2H), 4.59 (m, 2H), 6.02 (s, 1H), 6.41 ~ 7.29 (m, 11H)

MS (m/z):  $\text{MH}^+$  (430)

The racemic 5-[4-(2-Dimethylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol compound (890 mg) was loaded onto a ChiralPak AD chiral HPLC column ( 5 cm I.D. x 50 cm L) and eluted with 20% MeOH and 80% IPA at the 150 mL/min flow rate. The

two peaks were removed under vacuum to yield the enantiomers as follows:  
Peak 1: 5R<sup>+</sup>(+)-[4-(2-Dimethylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol

$[\alpha]_D = +38 (C=0.3, \text{MeOH})$

<sup>1</sup>H NMR (DMSO-d<sub>6</sub>)  $\delta$  2.13 (s, 6H), 2.43 ~ 2.92 (m, 4H), 3.95 (t, 2H, J = 6.6 Hz), 4.59 (m, 2H), 6.15 (s, 1H), 6.38 ~ 7.39 (m, 11H), 9.69 (s, 1H)

MS (m/z): MH<sup>+</sup> (430)

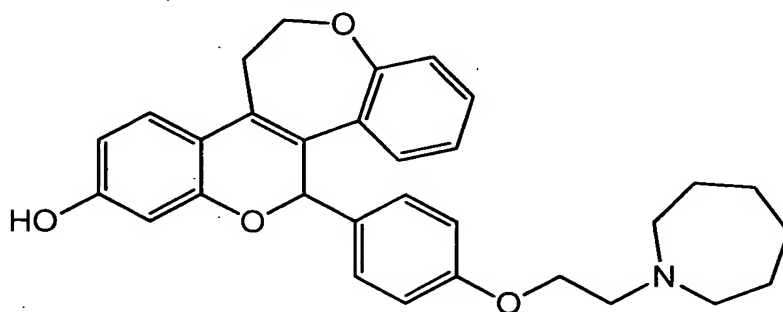
Peak 2: 5S<sup>-</sup>(-)-[4-(2-Dimethylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol

$[\alpha]_D = -36 (C=0.32, \text{MeOH})$

MS (m/z): MH<sup>+</sup> (430)

### Example 109

5-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-8-ol Compound #143



Following the procedure described in Example 106, 8-(tert-Butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol, the compound prepared as in Example 105, was reacted in sequence with 1-[2-(4-Iodo-phenoxy)-ethyl]-azepane, HCl and then HF•Pyridine to yield the title compound as a yellow solid.

$^1\text{H}$  NMR (Acetone- $d_6$ )  $\delta$  1.54 (m, 8H), 2.68 ~ 2.95 (m, 8H), 3.98 (m, 2H), 4.74 (m, 2H), 6.18 (s, 1H), 6.21 ~ 7.39 (m, 11H)

MS (m/z):  $\text{MH}^+$  (484).

5 The racemic 5-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-8-ol compound (840 mg) was loaded onto a ChiralPak AD chiral HPLC column ( 5 cm I.D. x 50 cm L) and eluted with 40% MeOH and 60% IPA at the 100 mL/min flow rate. The two peaks were removed under vacuum to yield the two enantiomers:

10 Peak 1: 5R<sup>+</sup>-(+)-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-8-ol

$[\alpha]_D = +37$  (c=0.11, MeOH)

$^1\text{H}$  NMR (DMSO- $d_6$ )  $\delta$  1.55 (broad s, 8H), 2.68 ~ 2.92 (m, 8H), 3.92 (t, 2H, J = 6.6 Hz), 4.61 (m, 2H), 6.14 ~ 7.38 (m, 12H). 9.56 (s, 1H)

15 MS (m/z):  $\text{MH}^+$  (484)

Peak 2: 5S<sup>-</sup>-(-)-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-8-ol

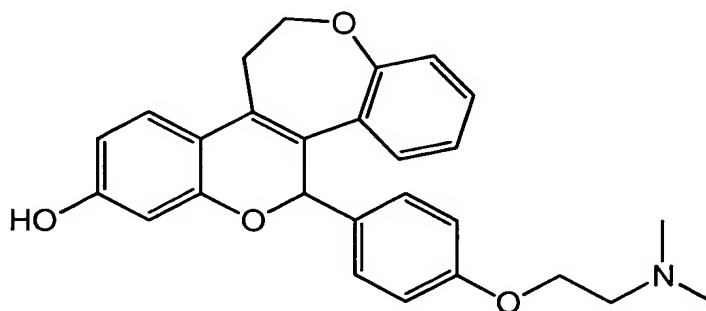
$[\alpha]_D = -39$  (c=0.51, MeOH)

20  $^1\text{H}$  NMR (DMSO- $d_6$ )  $\delta$  1.55 (broad s, 8H), 2.68 ~ 2.92 (m, 8H), 3.92 (t, 2H, J = 6.6 Hz), 4.61 (m, 2H), 6.14 ~ 7.38 (m, 12H). 9.56 (s, 1H)

MS (m/z):  $\text{MH}^+$  (484)

### Example 110

25 5-[4-(2-Dimethylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-8-ol Compound #144



Following the procedure described in Example 106, 8-(tert-Butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol, the compound prepared as in Example 104 was reacted in sequence with [2-(4-Iodo-phenoxy)-ethyl]-dimethyl-amine, HCl and then

5 HF•Pyridine to yield the title compound as a yellow solid.

MS (m/z):  $MH^+$  (430)

The racemic 5-[4-(2-Dimethylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-8-ol compound (800 mg)

10 was loaded onto a ChiralPak AD chiral HPLC column ( 5 cm I.D. x 50 cm L) and eluted with 100% IPA at the 150 mL/min flow rate. The two peaks were removed under vacuum to yield the two enantiomers as follows:

Peak 1: 5R\*-(+)-[4-(2-Dimethylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo benzo[3,4]cyclohepta[1,2-a]naphthalen-8-ol

15  $[\alpha]_D = +42 (c = 0.34, \text{MeOH})$ .

$^1\text{H}$  NMR (DMSO- $d_6$ )  $\delta$  2.12 (s, 6H), 2.49 ~ 2.90 (m, 4H), 3.95 (t, 2H, J = 6.6 Hz), 4.61 (m, 2H), 6.09 ~ 7.23 (m, 11H), 9.54 (s, 1H)

MS (m/z):  $MH^+$  (430)

Peak 2: 5S\*(-)-[4-(2-Dimethylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo benzo[3,4]cyclohepta[1,2-a]naphthalen-8-ol

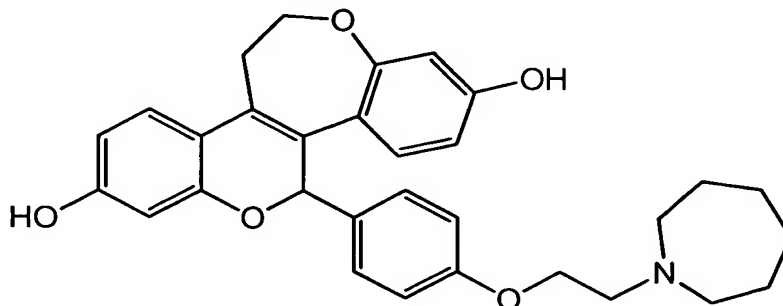
20

$[\alpha]_D = -42 (c = 0.34, \text{MeOH})$

MS (m/z):  $MH^+$  (430)

### Example 111

25 5-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol Compound #159



Following the procedure described in Example 106, 2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol, prepared as in Example 75 (1.5 g, 2.85 mmol) was reacted in sequence with 1-[2-(4-Iodo-phenoxy)-ethyl]-azepane, HCl and then  
 5 HF•Pyridine to yield the title compound as a foam.

$^1\text{H}$  NMR ( $\text{CDOD}_3$ )  $\delta$  1.65 (m, 4H), 1.84 (m, 4H), 2.78 (m, 2H), 3.35 (m, 4H), 3.48 (m, 2H), 4.18 (m, 2H), 4.61 (m, 2H), 6.02 (s, 1H), 6.18 ~ 7.35 (m, 10 H)

MS (m/z):  $\text{MH}^+$  (500),  $\text{MH}^-$  (498).

10

The racemic 5-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol compound (1.02g) was loaded onto a ChiralPak AD chiral HPLC column ( 5 cm I.D. x 50 cm L) and eluted with 100% IPA at the 150 mL/min flow rate. The two peaks  
 15 were removed under vacuum to yield the two enantiomers as follows:

Peak 1: 5R<sup>+</sup>-(+)-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol

$[\alpha]_D = + 33(c=0.11, \text{MeOH})$

MS (m/z):  $\text{MH}^+$  (500),  $\text{MH}^-$  (498)

20 Peak 2: 5S<sup>+</sup>-(-)-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol

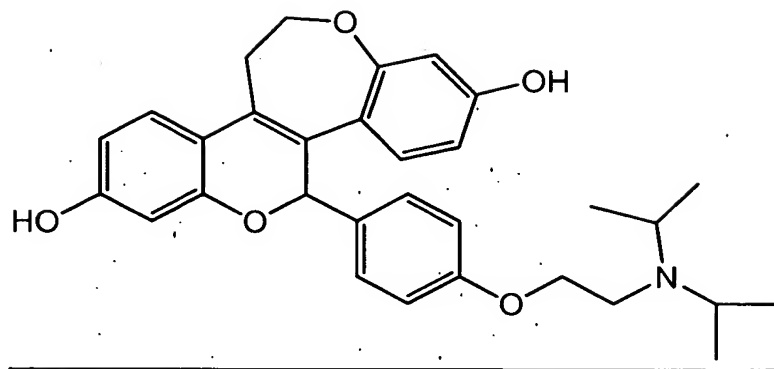
$[\alpha]_D = - 39(c=0.51, \text{MeOH})$

MS (m/z):  $\text{MH}^+$  (500),  $\text{MH}^-$  (498)

25

### Example 112

**5-[4-(2-Diisopropylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol Compound #160**



Following the procedure described in Example 106, 2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol, prepared as in Example 75 (1.5 g, 2.85 mmol) was reacted in sequence with [2-(4-Iodo-phenoxy)-ethyl]-diisopropyl-amine, HCl and then HF•Pyridine to yield the title compound as a pink solid.

$^1\text{H}$  NMR ( $\text{CDOD}_3$ )  $\delta$  1.28 (d, 12H,  $J = 5.3$  Hz), 2.78 (m, 2H), 3.25 (m, 2H), 3.52 (m, 2H), 4.05 (m, 2H), 4.56 (m, 2H), 6.05 ~ 7.35 (m, 11H).

MS ( $m/z$ ):  $\text{MH}^+$  (502),  $\text{MH}^-$  (500).

10

The racemic 5-[4-(2-Diisopropylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol compound (1.4 g) was loaded onto a ChiralPak AD chiral HPLC column (5 cm I.D. x 50 cm L) and eluted with 80% IPA and 20% Hexanes at the 150 mL/min flow rate. The two peaks were removed under vacuum to yield the two enantiomers as follows:

Peak 1: 5R<sup>+</sup>-(+)-[4-(2-Diisopropylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol

$[\alpha]_{\text{D}} = +43$  ( $c=0.112$ , MeOH)

20

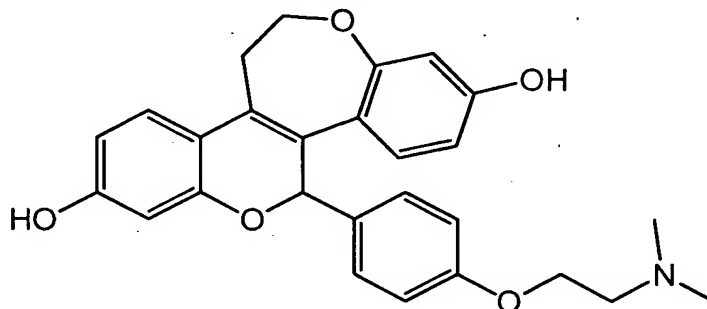
MS ( $m/z$ ):  $\text{MH}^+$  (502),  $\text{MH}^-$  (500)

Peak 2: 5S<sup>+</sup>-(-)-[4-(2-Diisopropylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol

$[\alpha]_{\text{D}} = -69$  ( $c=0.812$ , MeOH)

MS ( $m/z$ ):  $\text{MH}^+$  (502),  $\text{MH}^-$  (500)

25

**Example 113****5-[4-(2-Dimethylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol Compound #161**

5 Following the procedure described in Example 106, 2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol, prepared as in Example 75 (2.8 g, 5.3 mmol) was reacted in sequence with [2-(4-Iodo-phenoxy)-ethyl]-dimethyl-amine, HCl and then HF•Pyridine to yield the title compound as a yellow solid.

10  $^1\text{H}$  NMR ( $\text{CDOD}_3$ )  $\delta$  2.85 (s, 6H), 3.28 (m, 2H), 3.54 (m, 2H), 4.28 (m, 2H), 4.61 (m, 2H), 6.06 (s, 1H), 6.15 ~ 7.41 (m, 10 H).

MS (m/z):  $\text{MH}^+$  (446),  $\text{MH}^-$  (444).

15 The racemic 5-[4-(2-Dimethylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol compound (1.7 g) was loaded onto a ChiralPak AD chiral HPLC column ( 5 cm I.D. x 50 cm L) and eluted with 80% IPA and 20% Hexanes at the 150 mL/min flow rate. The two peaks were removed under vacuum to yield the two enantiomers as follows:

20 Peak 1:  $\text{R}^+$ -(+)-5-[4-(2-Dimethylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol.

$[\alpha]_D = +39$  (c=0.14, MeOH)

MS (m/z):  $\text{MH}^+$  (446),  $\text{MH}^-$  (444)

25 Peak 2:  $\text{S}^-$ -(-)-5-[4-(2-Dimethylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol

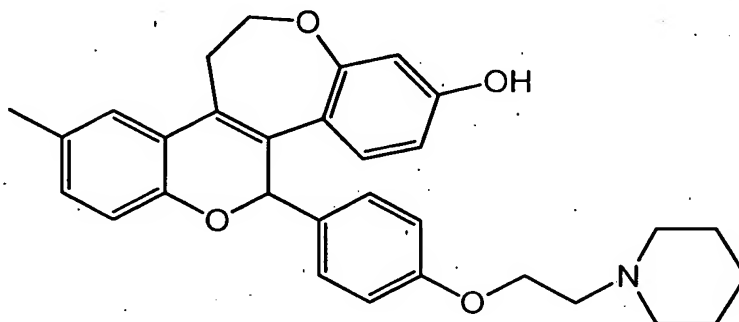
$[\alpha]_D = -49$  (c=0.4, MeOH)

MS (m/z):  $\text{MH}^+$  (446),  $\text{MH}^-$  (444)



**Example 114**

**9-Methyl-5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol Compound #283**



5

Following the procedure described in Example 106, 2-(tert-Butyl-dimethyl-silyloxy)-9-methyl-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol, prepared as in Example 106 (0.80 g, 1.95 mmol) was reacted in sequence with [2-(4-Iodo-phenoxy)-ethyl]-morpholine, HCl and then HF•Pyridine to yield the title compound as a yellow solid.

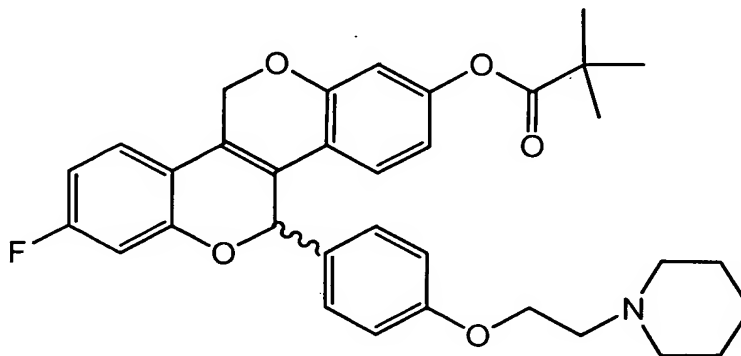
10

MS (m/z): MH<sup>+</sup> (484).

**Example 115**

**2,2-Dimethyl-propionic acid 8-fluoro-5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester Compound #87**

15



The title compound was prepared according to the procedure described in Example 54, substituting 5-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydrochromeno[4,3-c]chromene-2,8-diol with 8-Fluoro-5-[4-(2-

20

piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3c]chromen-2-ol, to yield a foam.

<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 1.18, 1.32 (9H, two s), 1.42 (2H, m), 1.63 (4H, m), 2.64 (4H, br s), 2.87 (2H, t, J = 5.5 Hz), 4.11 (2H, t, J = 5.5 Hz), 5.15 (1H, d, J = 14.0 Hz), 5.38 (1H, d, J = 14.0 Hz), 6.18 (1H, s), 6.48 ~ 7.31 (10H, m). MS (m/z): MH<sup>+</sup> (558).

The racemic 5-[4-(2-Dimethylamino-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol compound (1.7 g) was loaded onto a ChiralPak AD chiral HPLC column ( 5 cm I.D. x 50 cm L) and eluted with 100% IPA at the 100 mL/min flow rate. The two peaks were removed under vacuum to yield the two enantiomers as follows:

Peak 2: 2,2-Dimethyl-propionic acid 8-fluoro-5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester

m.p. 182 ~183 °C

[α] = + 160 °(c = 0.225, CHCl<sub>3</sub>)

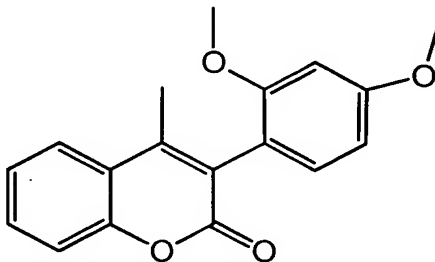
Peak 1: 2,2-Dimethyl-propionic acid 8-fluoro-5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester

m.p. 178 ~179 °C

[α] = - 173 °(c = 0.205, CHCl<sub>3</sub>)

### Example 116

#### 3-(2,4-Dimethoxy-phenyl)-4-methyl-chromen-2-one compound #239



The title compound was prepared according to the procedure described in Example 1, substituting 2,4-dimethoxy acetophenone with 2-hydroxy acetophenone, to yield a yellow solid.

MS (m/z):  $MH^+$  (297),  $MNa^+$  (319),  $2MNa^+$  (615).

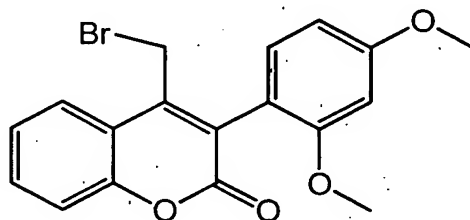
$^1H$  NMR ( $CDCl_3$ )  $\delta$  6.65 ~ 7.69 (m, 7H), 3.83 (s, 3H), 3.73 (s, 3H), 2.32 (s, 3H).

5

**Example 117**

**4-Bromomethyl-3-(2,4-dimethoxy-phenyl)-chroman-2-one Compound**

**#240**



The title compound was prepared according to the procedure described in Example 63, substituting 3-(2,4-dihydroxyphenyl)-7-hydroxy-4-methyl-chromen-2-one with 3-(2,4-dimethoxy-phenyl)-4-methyl-chromen-2-one, and replacing bromine by NBS, to yield a yellow solid.

10

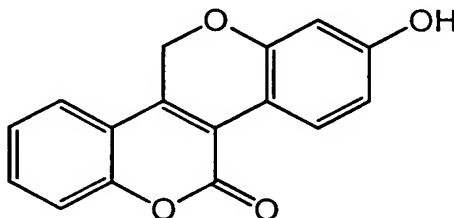
$^1H$  NMR ( $CDCl_3$ )  $\delta$  7.08 ~ 7.61 (m, 5H), 6.41 (m, 2H), 4.39 (1H, d, J = 10.1 Hz), 4.12 (1H, d, J = 10.1 Hz).

15

MS (m/z):  $MNa^+$  (399),  $2MNa^+$  (773).

**Example 118**

**2-Hydroxy-11H-chromeno[4,3-c]chromen-5-one Compound #218**



20

To a mixture of 4-bromomethyl-3-(2,4-dimethoxy-phenyl)-2H-chromene (25.8 g, 68.76 mmol) in  $CH_2Cl_2$  (1.27 L) under nitrogen was slowly added  $BBr_3$  (1.0 M in  $CH_2Cl_2$ , 310 mL, 4.5 eq.) at 25°C. After 16 h stirring, the reaction mixture was poured into a cold solution of saturated  $NaHCO_3$  (700 mL) and water (700 mL). Aqueous NaOH solution (75 mL, 10 N) was then added to the reaction mixture. The aqueous layer was separated and then acidified

25

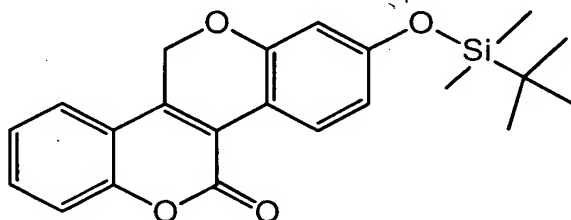
with aqueous (10 N) to pH~1.0 resulting in the formation of a yellow solid that was filtered, washed with water and air-dried under vacuum overnight to yield title compound as yellow solid.

<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 9.95 (1H, s), 8.24 (d, 1H, J = 8.7 Hz), 7.79 (1H, J = 7.9 Hz), 7.62 (1H, t, J = 7.2 Hz), 7.41 (m, 2H), 6.55 ~ 6.42 (2H, m), 5.42 (2H, s).

MS (m/z): MH<sup>+</sup> (267), MNa<sup>+</sup> (289).

### Example 119

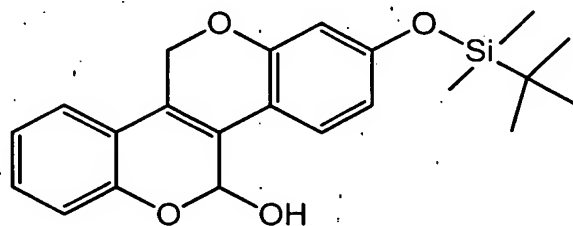
2-(tert-Butyl-dimethyl-silyloxy)-11H-chromeno[4,3-c]chromen-5-one  
Compound #219



2-Hydroxy-11H-chromeno[4,3-c]chromen-5-one (0.5g) prepared as in Example 118 was dissolved in THF (5 mL). To the reaction mixture was then added triethylamine (1.5 mL) and 1M TBSCl (2.0 mL) in dichloromethane and the reaction mixture stirred at room temperature for 1h. The reaction mixture was diluted with ethyl acetate (100 mL) and then washed twice with brine. The organic layer was dried over anhydrous sodium sulfate and concentrated. The crude product was purified by flash chromatography eluted with 100:10:2 hexane/dichloromethane/ethyl acetate, to yield title compound as a solid.

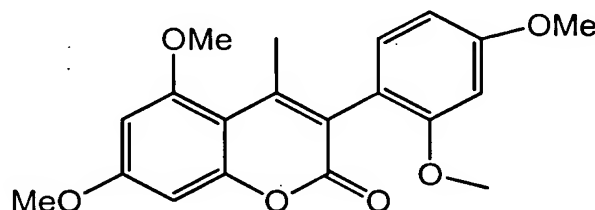
<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 8.43 (1H, d, J = 8.7 Hz), 7.58 ~ 7.28 (m, 4H), 6.59 ~ 6.43 (m, 2H), 5.31 (2H, s).

MS (m/z): MH<sup>+</sup> (381), MNa<sup>+</sup> (403).

**Example 120****2-(tert-Butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-ol Compound #135**

5 The title compound was prepared according to the procedure described in Example 24, replacing 2, 8-bis-(*tert*-butyl-dimethyl-silyloxy)-11*H*-chromeno[4,3-*c*]chromen-5-one with 2-(*tert*-butyl-dimethyl-silyloxy)-11*H*-chromeno[4,3-*c*]chromen-5-one, to yield a solid.

<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 7.28 ~ 7.02 (m, 4H), 6.48 ~ 6.32 (m, 3H), 5.32 ~ 5.13 (m, 2H), 3.09 (1H, d, J = 7.6 Hz),  
 10 MS (m/z): MNa<sup>+</sup> (405).

**Example 121****3-(2,4-Dimethoxy-phenyl)-5,7-dimethoxy-4-methyl-chromen-2-one Compound #284**

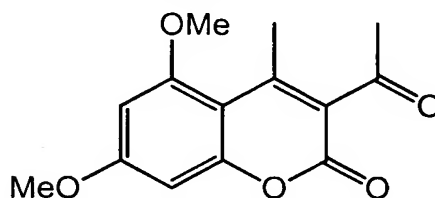
15 The title compound was prepared according to the procedure described in Example 1, replacing 2,4-dihydroxy acetophenone with 1-(2-Hydroxy-4,6-dimethoxy-phenyl)-ethanone, to yield a yellow solid.

20 <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 7.08 ~ 6.28 (m, 6H), 3.86 (6H, s), 3.84 (3H, s), 3.76 (3H, s), 2.34 (s, 3H).

MS (m/z): MH<sup>+</sup> (357), MNa<sup>+</sup> (379).

**Example 122**

**3-Acetyl-5,7-dimethoxy-4-methyl-chromen-2-one**



The title compound was isolated as a side product in the synthesis described in Example 123 above.

m.p. 166 ~167 °C

Anal. Calculated for  $C_{14}H_{14}O_5$ : C, 64.12; H, 5.38;

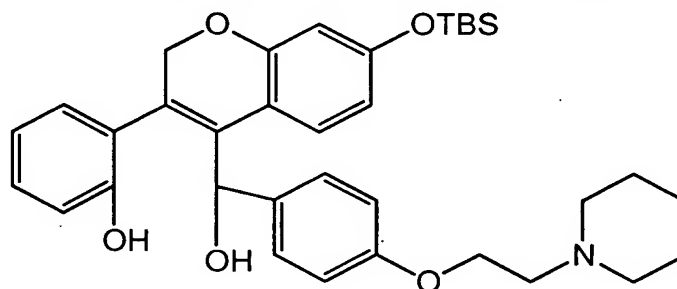
Measured: C, 64.20; H, 5.43.

$^1H$  NMR ( $CDCl_3$ )  $\delta$  6.42 (1H, d, J = 2.3 Hz), 6.37 (1H, d, J = 2.3 Hz), 3.89 (s, 3H), 2.61 (s, 3H), 2.41 (s, 3H).

MS (m/z):  $MH^+$  (263),  $MNa^+$  (285),  $2MNa^+$  (547).

**Example 123**

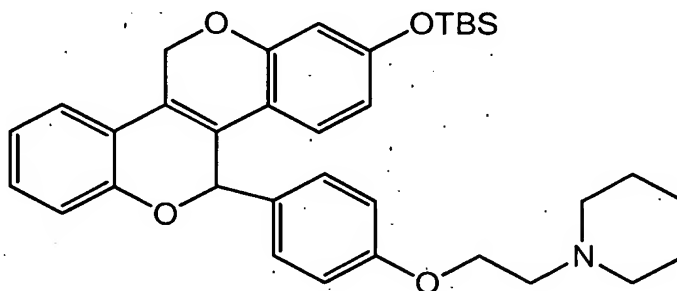
**2-(7-(tert-Butyl-dimethyl-silyloxy)-4-{hydroxy-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-methyl}-2H-chromen-3-yl)-phenol**



The title compound was prepared according to the procedure for described in Example 26, replacing 2, 8-bis-(tert-Butyl-dimethyl-silanlyoxy)-5,11-dihydro-chromeno [4,3-c]-chromen-5-ol with 2-(tert-Butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-ol, to yield a oil.

$^1H$  NMR ( $CDCl_3$ )  $\delta$  7.24 ~ 6.15 (m, 11H), 5.46 (s, 1H), 4.92 (m, 2H), 4.18 (br s, 2H), 3.02 (br s, 2H), 2.78 (br s, 4H), 1.78 (br s, 4H), 1.52 (br s, 2H), 0.92 (s, 9H), 0.14 (s, 6H)

MS (m/z):  $MH^+$  (588),  $MH^+$  (586).

**Example 124****1-(2-{4-[2-(tert-Butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-phenoxy}-ethyl)-piperidine Compound #158**

5

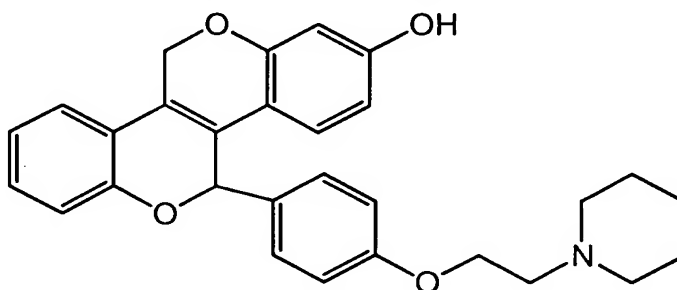
The title compound was prepared according to the procedure described in Example 35, replacing 5-(tert-butyl-dimethyl-silyloxy)-2-(7-(tert-butyl-dimethyl-silyloxy)-4-{hydroxy-[4-(2-piperidine-1-yl-ethoxy)-phenyl]-methyl}-2H-chromen-3-yl)-phenol with 1-(2-{4-[2-(tert-Butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-phenoxy}-ethyl)-piperidine, to yield a foam.

10

$^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  7.16 ~ 6.12 (m, 11H), 6.05 (s, 1H), 5.15 (1H, d, J = 14.1 Hz), 4.95 (1H, d J = 14.1 Hz), 4.16 (2H, br s), 3.05 (br s, 2H), 2.81 (br s, 4H), 1.72 (br s, 4H), 1.38 (br s, 2H), 0.79 (s, 9H), 0.19 (s, 9H).

15

MS (m/z):  $\text{MH}^+$  (570).

**Example 125****5-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-ol Compound #133**

20

The title compound was prepared according to the procedure described in Example 44, replacing 1-(2-{4-[2,8-Bis-(tert-butyl-dimethyl-

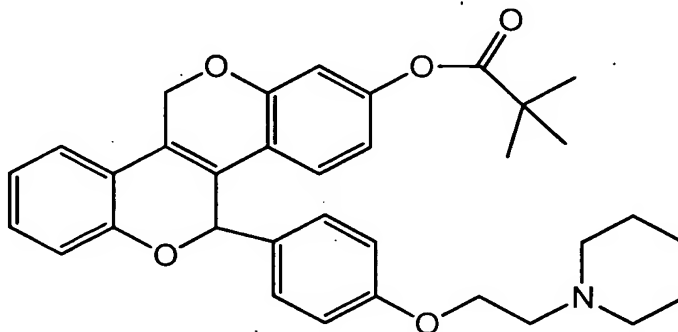
silyloxy)-5,11-dihydro-chromeno[4,3-c]-chromen-5-yl]-phenoxy}-ethyl)-piperidine with 1-(2-{4-[2-(tert-Butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-phenoxy}-ethyl)-piperidine, to yield a solid.

<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 7.39 ~ 6.31 (m, 12H), 5.45 (1H, d, J = 14.2 Hz), 5.15 (1H, d, J = 14.2 Hz), 4.02 (t, 2H, J = 6.2 Hz), 2.65 (t, 2H, J = 6.2 Hz), 2.45 (br s, 4H), 2.05 (br s, 4H), 1.51 (m, 2H).

MS (m/z): MH<sup>+</sup> (456).

### Example 126

2,2-Dimethyl-propionic acid 5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester Compound 134



The title compound was prepared according to the procedure described in Example 54, replacing 5-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydrochromeno[4,3-c]chromene-2,8-diol with 5-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-ol, prepared as in Example 127, to yield a solid.

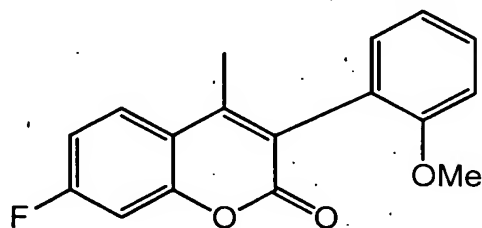
<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 7.38 ~ 6.38 (m, 11H), 6.21 (s, 1H), 5.40 (1H, d, J = 14.0 Hz), 5.18 (1H, d, J = 14.0 Hz), 4.13 (2H, t, J = 5.5 Hz), 2.95 (2H, t, J = 5.4 Hz), 2.71 (br s, 4H), 1.68 (br m, 4H), 1.47 (m, 2H), 1.32 (s, 9H).

MS (m/z): MH<sup>+</sup> (539).



**Example 127**

**7-Fluoro-3-(2-methoxy-phenyl)-4-methyl-chromen-2-one Compound #284**



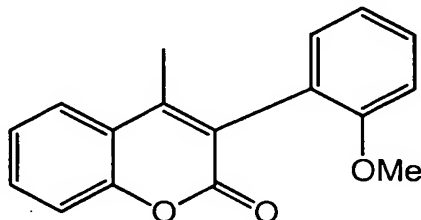
The title compound was prepared according to the procedure described in Example 1, replacing 2,4-dihydroxy acetophenone with fluoro-2-hydroxy-phenyl)-ethanone and replacing 2,4-dimethoxyphenyl acetic acid with 2-methoxy phenyl acetic acid. 1-(4-Fluoro-2-hydroxy-phenyl)-ethanone, to yield a solid.

$^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  7.65 ~ 6.94 (m, 6H), 3.79 (s, 3H), 2.23 (s, 3H).

MS (m/z):  $\text{MH}^+$  (285),  $\text{MNa}^+$  (307).

**Example 128**

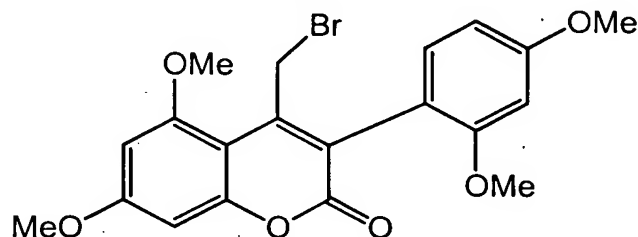
**3-(2-Methoxy-phenyl)-4-methyl-chromen-2-one Compound #241**



The title compound was prepared according to the procedure described in Example 1, replacing 2,4-dihydroxy-acetophenone by 1-(2-Hydroxy-phenyl)-ethanone and 2,4-dimethoxy-phenylacetic-acid with 2-methoxy-phenyl acetic acid, to yield a solid.

$^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  7.68 ~ 6.96 (m, 8H), 3.79 (s, 3H), 2.25 (s, 3H).

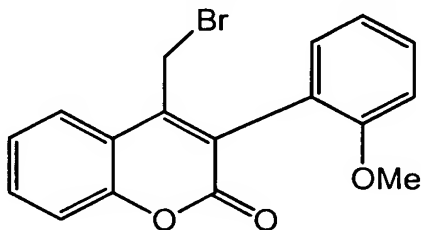
MS (m/z):  $\text{MH}^+$  (267),  $\text{MNa}^+$  (289).

**Example 129****4-Bromomethyl-3-(2,4-dimethoxy-phenyl)-5,7-dimethoxy-chromen-2-one****Compound #242**

5 The title compound was prepared according to the procedure described in Example 63, replacing 3-[2,4-bis-(2-trimethylsilyl-ethoxymethoxy)-phenyl]-4-methyl-7-(2-trimethylsilyl-ethoxymethoxy)-chromen-2-one with 3-(2,4-Dimethoxy-phenyl)-5,7-dimethoxy-4-methyl-chromen-2-one, and bromine with NBS (1.1 eq.), to yield a solid.

10  $^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  7.28 ~ 6.38 (m, 5H), 4.49 (d, 1H,  $J = 8.8$  Hz), 4.31 (d, 1H,  $J = 8.8$  Hz), 3.94 (s, 3H), 3.87 (s, 3H), 3.85 (s, 3H), 3.75 (s, 3H).

MS ( $m/z$ ):  $\text{MH}^+$  (436, 438),  $\text{MNa}^+$  (457, 459).

**Example 130****4-Bromomethyl-3-(2-methoxy-phenyl)-chromen-2-one Compound #243**

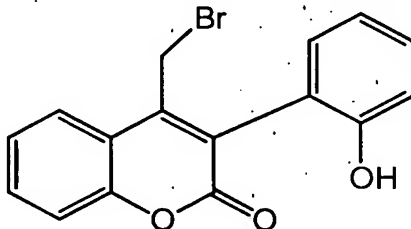
15 The title compound was prepared according to the procedure described in in Example 63, replacing 3-[2,4-bis-(2-trimethylsilyl-ethoxymethoxy)-phenyl]-4-methyl-7-(2-trimethylsilyl-ethoxymethoxy)-chromen-2-one with 3-(2-Methoxy-phenyl)-4-methyl-chromen-2-one, and replacing bromine with NBS (1.1 eq.) instead of  $\text{Br}_2$ , to yield a solid.

20  $^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  7.82 ~ 7.01 (m, 8H), 4.44 (d, 1H,  $J = 10.2$  Hz), 4.25 (d, 1H,  $J = 10.2$  Hz).

MS ( $m/z$ ):  $\text{MH}^+$  (347),  $\text{MNa}^+$  (369).

**Example 131**

**4-Bromomethyl-3-(2-hydroxy-phenyl)-chromen-2-one Compound 244**



5 The title compound was prepared according to the same procedure described in Example 120, replacing 4-bromomethyl-3-(2,4-dimethoxy-phenyl)-2H-chromene with 4-bromomethyl-3-(2-methoxy-phenyl)-chromen-2-one, to yield a solid.

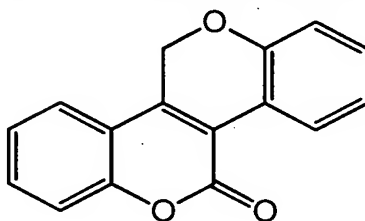
m.p. 213 ~ 215 °C.

10  $^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  7.82 ~ 7.01 (m, 8H), 5.02 (s, 1H), 4.50 (1H, d, J = 10.2 Hz), 4.30 (1H, d, J = 10.2 Hz).

MS (m/z):  $\text{MH}^+$  (333),  $\text{MNa}^+$  (355).

**Example 132**

**11H-Chromeno[4,3-c]chromen-5-one**



15 The title compound was prepared according to the procedure described in Example 61, starting from 4-bromomethyl-3-(2-hydroxy-phenyl)-chromen-2-one instead of 4-bromomethyl-3-(2,4-dibenzoyl-phenyl)-7-benzoyl-chromen-2-one, to yield a solid.

Anal. Calculated for  $\text{C}_{16}\text{H}_{11}\text{BrO}_3$ : C, 58.03; H, 3.35.

Measured: C, 58.02; H, 3.29.

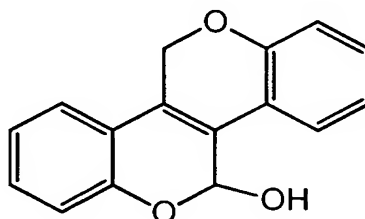
m. p. 201.5 ~ 202.0 °C.

$^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  8.61 ~ 7.01 (m, 8H), 5.34 (s, 2H).

MS (m/z):  $MH^+$  (333),  $MNa^+$  (355).

**Example 133**

**5,11-Dihydro-chromeno[4,3-c]chromen-5-ol Compound 136**



5

The title compound was prepared according to the procedure described in Example 24, starting from 11H-Chromeno[4,3-c]chromen-5-one instead 2, 8-bis-(*tert*-butyl-dimethyl-silyloxy)-11H-chromeno[4,3-c]chromen-5-one, to yield a solid.

10

Anal. Calculated for  $C_{16}H_{12}O_3$ : C, 76.18; H, 4.79.

Measured: C, 75.86; H, 4.70.

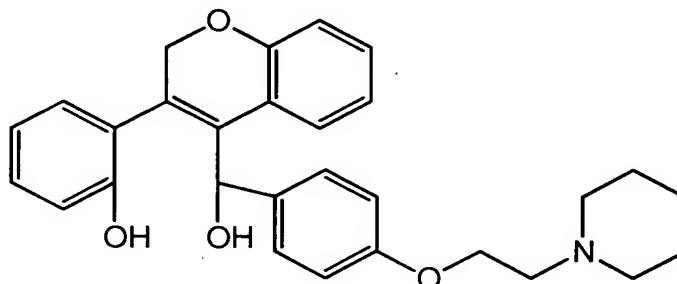
$^1H$  NMR ( $CDCl_3$ )  $\delta$  7.34 ~ 6.86 (m, 8H), 6.41 (d, 1H,  $J = 6.3$  Hz), 5.22 (m, 2H), 3.12 (d, 1H,  $J = 7.8$  Hz).

MS (m/z):  $MH^+$  (253),  $MNa^+$  (275).

15

**Example 134**

**2-(4-{Hydroxy-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-methyl}-2H-chromen-3-yl)-phenol Compound #246**



20

The title compound was prepared according to the procedure described in Example 26, starting from 2-(*tert*-Butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromen-5-ol replacing 2, 8-bis-(*tert*-Butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno [4,3-c]-chromen-5-ol to yield a solid.

Anal. Calculated for  $C_{29}H_{31}NO_4 \cdot 0.75 H_2O$ :

C, 73.94; H, 6.95, N, 2.97.

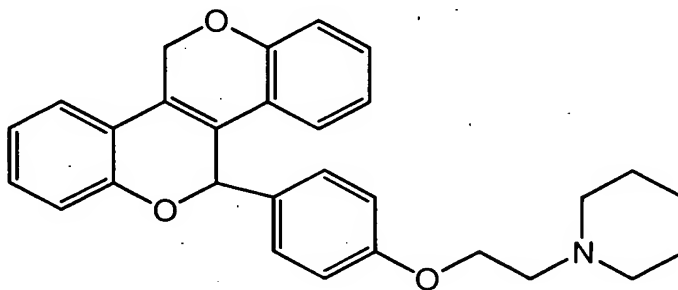
Measured: C, 73.98; H, 6.92, N, 2.97.

$^1H$  NMR ( $DMSO-d_6$ )  $\delta$  9.80 (s, 1H), 7.48 ~ 6.59 (m, 12H), 5.87 (br s, 1H), 5.58 (br s, 1H), 5.01 (br d, 1H), 4.64 (br d, 1H), 3.98 (br s, 2H), 2.58 (br s, 2H), 2.37 (br s, 4H), 1.42 (br s, 4H), 1.34 (br s, 2H).

MS (m/z):  $MH^+$  (458).

### Example 135

#### 10 1-{2-[4-(5,11-Dihydro-chromeno[4,3-c]chromen-5-yl)-phenoxy]-ethyl}- piperidine Compound #137



The title compound was prepared according to the procedure described in Example 35, starting from 2-(4-{Hydroxy-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-methyl}-2H-chromen-3-yl)-phenol instead 5-(*tert*-butyl-dimethyl-silyloxy)-2-(7-(*tert*-butyl-dimethyl-silyloxy)-4-{hydroxy-[4-(2-piperidine-1-yl-ethoxy)-phenyl]-methyl}-2H-chromen-3-yl)-phenol, to yield a solid.

Anal. Calculated for  $C_{29}H_{29}NO_3$ : C, 79.24; H, 6.65, N, 3.19.

20 Measured: C, 78.96; H, 6.57, N, 3.11.

$^1H$  NMR ( $CDCl_3$ )  $\delta$  7.38 ~ 6.71 (m, 12H), 6.22 (s, 1H), 5.38 (d, 1H, J = 14.0 Hz), 5.15 (d, 1H, J = 14.1 Hz), 4.03 (t, 2H, J = 6.1 Hz), 2.71 (t, 2H, J = 6.1 Hz), 2.45 (br s, 4H), 1.55 (br s, 4H), 1.45 (br m, 2H).

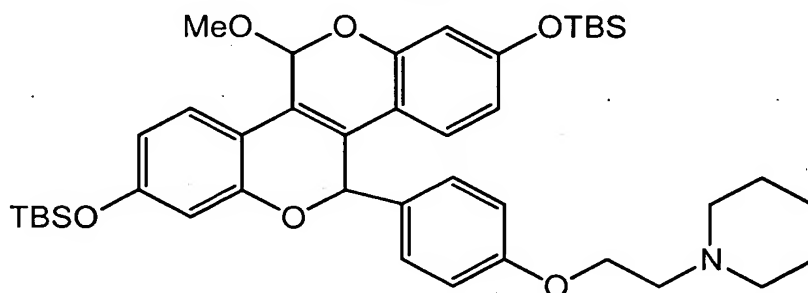
MS (m/z):  $MH^+$  (440).

25

**Example 136**

**1-(2-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11-methoxy-5,11-dihydro-chromeno[4,3-c]chromen-5-yl]-phenoxy}-ethyl)-piperidine Compound**

**#162**



5

The title compound was isolated by flash chromatography, as a by-product of the reaction described in Example 35.

$^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  7.38 ~ 6.10 (m, 11H), 5.91 (s, 1H), 4.41 (br s, 2H), 3.61 (s, 3H), 3.21 (br s, 2H), 3.15 (br m, 4H), 1.95 (br s, 4H), 1.54 (br s, 2H), 0.91 (m, 18H), 0.21 (m, 12H).

10

MS ( $m/z$ ):  $\text{MH}^+$  (730).

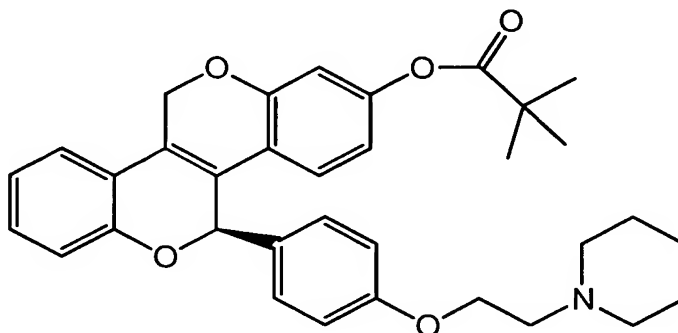
**Example 137**

**2,2-Dimethyl-propionic acid 5R\*(-)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester Compound #172**

15

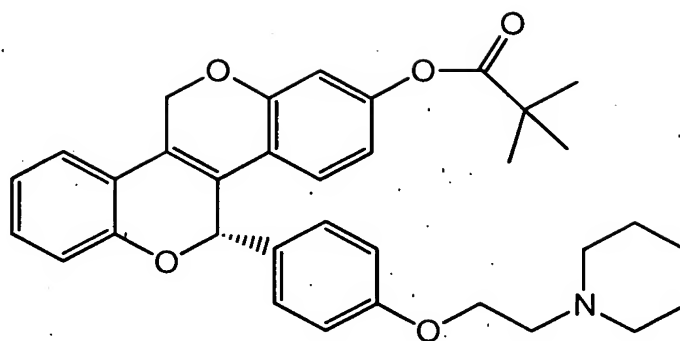
and

**2,2-Dimethyl-propionic acid 5S\*(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester Compound #171**



20

and



The racemic 2,2-Dimethyl-propionic acid 5S\*-(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester compound, prepared as in Example 126, (400mg ) was loaded onto a ChiralPak AD chiral HPLC column ( 5 cm I.D. x 50 cm L) and eluted with 80% IPA and 20% Hexanes at the 150 mL/min flow rate. The two peaks were removed under vacuum to yield the two enantiomers as follows:

Peak 1: 2,2-Dimethyl-propionic acid 5R\*(-)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester

10       $[\alpha] = -91^\circ$  (c = 0.21, CHCl<sub>3</sub>).

Peak 2: 2,2-Dimethyl-propionic acid 5S\*-(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester

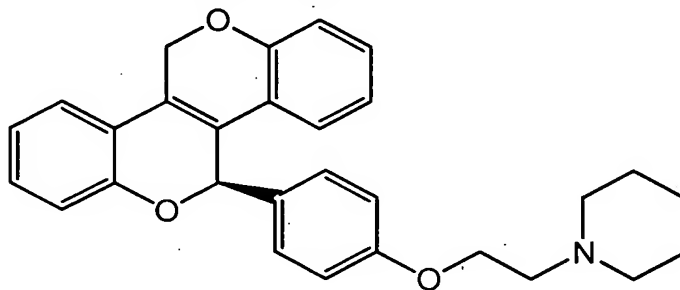
$[\alpha] = +102^\circ$  (c = 0.31, CHCl<sub>3</sub>).

**Example 138**

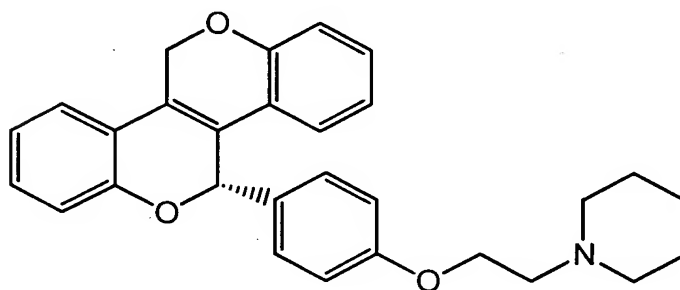
**5R\*(-)-1-{2-[4-(5,11-Dihydro-chromeno[4,3-c]chromen-5-yl)-phenoxy]-ethyl}-piperidine Compound #170**

and

5 **5S\*(+)-1-{2-[4-(5,11-Dihydro-chromeno[4,3-c]chromen-5-yl)-phenoxy]-ethyl}-piperidine Compound #169**



and



10 The racemic 2,2-Dimethyl-propionic acid 5S\*(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester compound, prepared as in Example 135, (900mg ) was loaded onto a ChiralPak AD chiral HPLC column ( 5 cm I.D. x 50 cm L) and eluted with 50% IPA and 50% Hexanes at the 200 mL/min flow rate. The two peaks were removed under  
15 vacuum to yield the two enantiomers as follows:

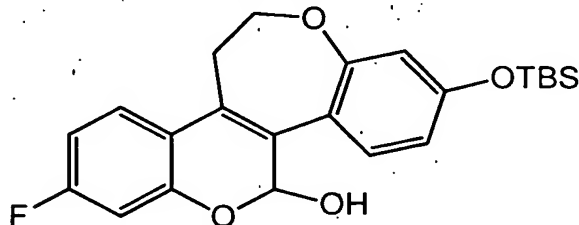
Peak 1: 5R\*(-)-1-{2-[4-(5,11-Dihydro-chromeno[4,3-c]chromen-5-yl)-phenoxy]-ethyl}-piperidine

$[\alpha] = -135^\circ$  (c = 0.27, CHCl<sub>3</sub>).

Peak 2: 5S\*(+)-1-{2-[4-(5,11-Dihydro-chromeno[4,3-c]chromen-5-yl)-phenoxy]-ethyl}-piperidine  
20

$[\alpha] = +146^\circ$  (c = 0.27, CHCl<sub>3</sub>).



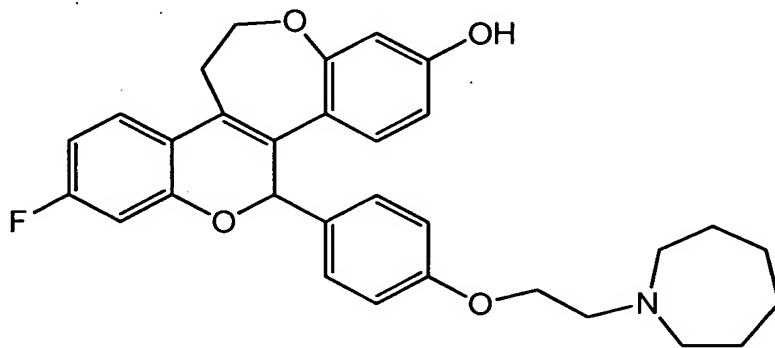
**Example 139****2-(tert-Butyl-dimethyl-silyloxy)-8-fluoro-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol Compound #286**

5 A solution of 2-(tert-Butyl-dimethyl-silyloxy)-8-fluoro-11,12-dihydro-6,13-dioxabenzo[3,4]cyclohepta[1,2-a] naphthalen-5-one (1.56g, 3.7 mmol) in toluene (40 mL) was treated with DIBAL (2.53 mL, 1.5 M in toluene, 1.0 eq.) at  $-78^{\circ}\text{C}$  for 3 hours. The reaction mixture was then quenched with chilled MeOH at  $-78^{\circ}\text{C}$  and the solvent was removed under reduced pressure. The  
10 residue was purified by flash chromatograph (10% EtOAc in hexanes) to yield the title compound as a white solid.

MS (m/z):  $\text{MH}^+$  (416).

**Example 140**

15 **5-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-8-fluoro-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol Compound #174**



The title compound was prepared according to the procedure described in Example 106, substituting 2-(tert-Butyl-dimethyl-silyloxy)-8-fluoro-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol (1.1 g) for 2-(tert-Butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol to yield a yellow solid.  
20

<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 1.61 (m, 8H), 2.71 ~ 2.99 (m, 8H), 3.92 (t, 2H, J = 6.6 Hz), 4.66 (m, 2H), 6.08 (s, 1H), 6.46 ~ 7.36 (m, 10H)

MS (m/z): M+H=502

5           The racemic 5-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-8-fluoro-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol compound (700 mg) was loaded onto a ChiralPak AD chiral HPLC column ( 5 cm I.D. x 50 cm L) and eluted with 80% IPA and 20% Hexanes at the 150 mL/min flow rate. The two peaks were removed under vacuum to yield the two  
10       enantiomers as follows:

Peak 1: 5R\*-(+)-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-8-fluoro-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol

$[\alpha]_D = +24.2 (c=0.305, \text{MeOH})$

MS (m/z): M+H=502

15 Peak 2: 5S\*(-)-[4-(2-Azepan-1-yl-ethoxy)-phenyl]-8-fluoro-11,12-dihydro-5H-  
6,13-dioxa-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol

$[\alpha]_D = -28.2 (c=0.5, \text{MeOH})$ .

MS (m/z): M+H=502

20 **Example 141**

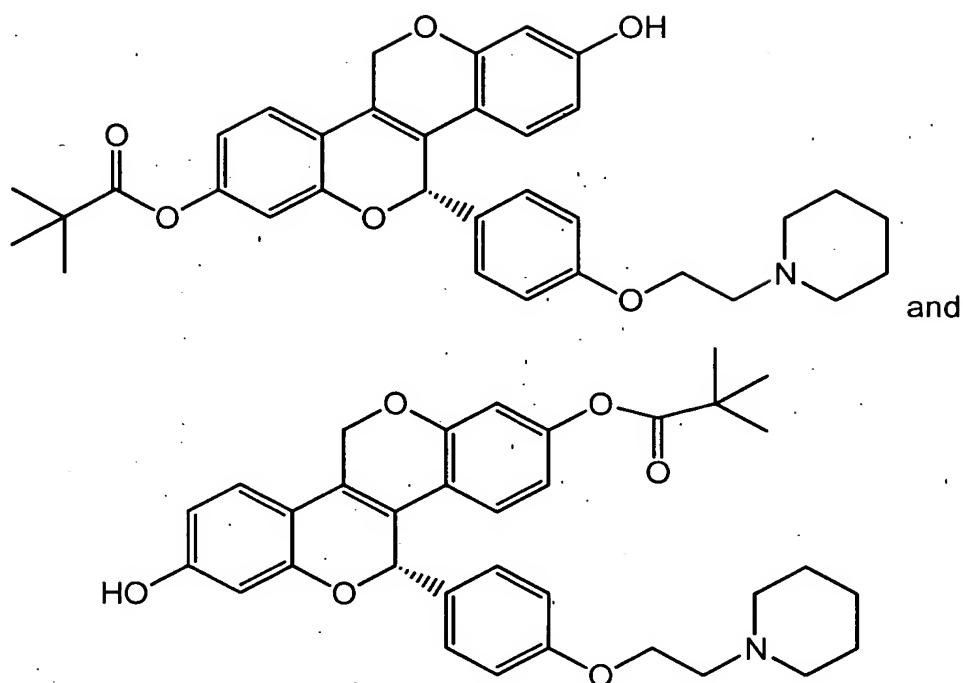
**2,2-Dimethyl-propionic acid 8-hydroxy-11S<sup>+</sup>-(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester**

### Compound #89

**and**

25 **2,2-Dimethyl-propionic acid 8-hydroxy-5S\*(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester**

### Compound #90



Dimethyl-propionic acid 8-(2,2-dimethyl-propionyloxy)-5S\*-(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester, prepared as in Example 67, (10 g) was suspended in MeOH (200 mL) and 1.2 equivalents of diethylamine were added into a sealed tube. The resulting solution was heated to 150°C for 3 h. The reaction mixture was concentrated on vacuum and purified on SiO<sub>2</sub> to yield a mixture of

The mixture (3.1g) was loaded onto a ChiralPak AD chiral HPLC column (5 cm I.D. x 50 cm L) and eluted with 100% IPA at the 150 mL/min flow rate. The two peaks were removed under vacuum to yield the two regio-isomers as follow:

Peak 1: 2,2-Dimethyl-propionic acid 8-hydroxy-5S\*(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester

<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 1.35 (s, 9H), 1.45 (broad s, 2H), 1.62 (broad s, 4H), 2.61 (broad s, 4H), 2.82 (broad s, 2H), 3.92 (t, 2H, J = 6.0 Hz), 5.05 (d, 1H, J = 14.7 Hz), 5.25 (d, 1H, J = 14.7 Hz), 6.12 ~ 7.22 (m, 11H)

MS (m/z): MH<sup>+</sup> (556).

Peak 2: 2,2-Dimethyl-propionic acid 8-hydroxy-11S\*-(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester

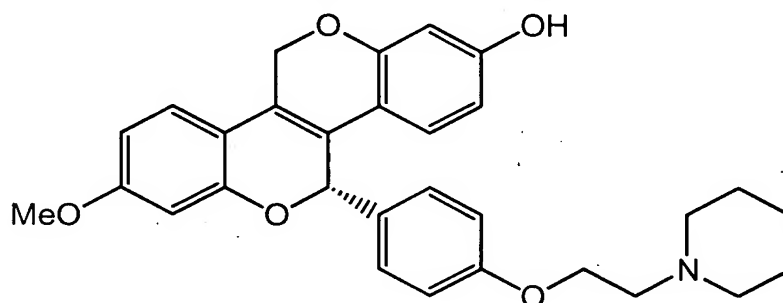
$^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  1.19 (d, 9H,  $J = 7.0$  Hz), 1.42 (broad s, 2H), 1.61 (broad s, 4H), 2.59 (broad s, 4H), 2.72 (broad s, 2H), 4.06 (m, 2H), 5.05 (d, 1H,  $J = 13.2$  Hz), 5.24 (d, 1H,  $J = 13.2$  Hz), 6.16 ~ 7.23 (m, 11H)

MS ( $m/z$ ):  $\text{MH}^+$  (556).

5

### Example 142

#### 8-Methoxy-5S-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-ol Compound #176

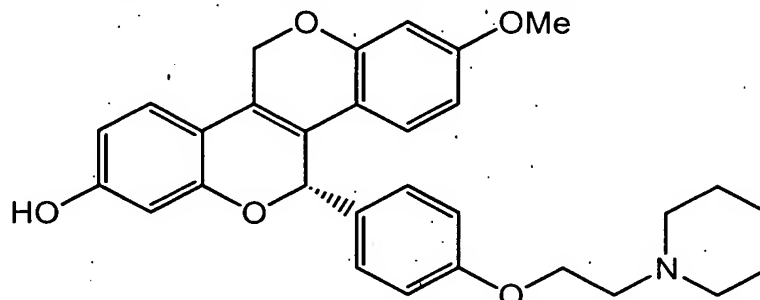


10 2,2-Dimethyl-propionic acid 8-hydroxy-5S\*(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester (330 mg) the compound prepared as in Example 145 above, was dissolved in  $\text{CH}_3\text{CN}/\text{MeOH}$  (3:1) (8 mL).  $\text{TMSCHN}_2$  (2M in hexane 3.3 mL) and was stirred over night. The reaction mixture was concentrated to dryness. The resulting  
15 crude oil was suspended in MeOH (5 mL) and TEA (0.800 mL) and heated in a sealed tube at  $150^\circ\text{C}$  overnight. The reaction mixture was concentrated and purified on  $\text{SiO}_2$  using 5-10% MeOH in  $\text{CH}_2\text{Cl}_2$ . to yield the title compound as a yellow foam.

20  $^1\text{H}$  NMR ( $\text{CDOD}_3$ )  $\delta$  1.48 (m, 2H), 1.61 (m, 4H), 2.59 (broad s, 4H), 2.79 (t, 2H,  $J = 5.6$  Hz), 4.08 (t, 2H,  $J = 5.6$  Hz), 5.02 (d, 1H,  $J = 13.8$  Hz), 5.31 (d, 1H,  $J = 13.6$  Hz)

MS ( $m/z$ ):  $\text{MH}^+$  (486).

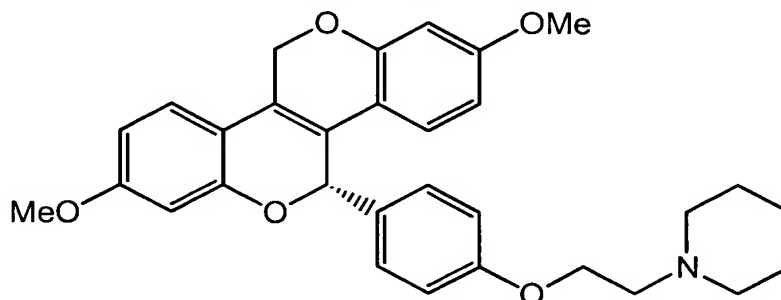
25

**Example 143****8-Methoxy-11S\*(-)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-ol Compound #181**

- 5            2,2-Dimethyl-propionic acid 8-hydroxy-11S\*(-)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester (300 mg), the compound prepared as in Example 145, was dissolved in CH<sub>3</sub>CN/MeOH(3:1) (8 mL). TMSCHN<sub>2</sub> (2M in hexane, 3.3 mL) and was stirred overnight. The reaction mixture was concentrated to dryness. The
- 10           resulting crude oil was suspended in MeOH (5 mL) and TEA (0.8 mL) and heated in a sealed tube at 150°C overnight. The reaction mixture was concentrated and purified on SiO<sub>2</sub> using 5-10% MeOH in CH<sub>2</sub>Cl<sub>2</sub>. to yield the title compound as a yellow foam.

MS (m/z): MH<sup>+</sup> (486).

15

**Example 144****5S\*(-)-1-{2-[4-(2,8-Dimethoxy-5,11-dihydro-chromeno[4,3-c]chromen-5-yl)-phenoxy]-ethyl}-piperidine Compound #173**

- 20            5S\*(-)-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromene-2,8-diol (290 mg) , prepared as in Example 78, was dissolved in CH<sub>3</sub>CN/MeOH (3:1) (5 mL). TMSCHN<sub>2</sub> (2M in hexane, 4 mL) and was stirred

overnight. The reaction mixture was concentrated to dryness and purified over SiO<sub>2</sub> using 5% MeOH in CH<sub>2</sub>Cl<sub>2</sub>, to yield the title compound as a colorless oil.

<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 1.41 (broad s, 2H), 1.62 (broad s, 4H), 2.53 (broad s, 4H), 2.79 (s, 2H), 3.81 (s, 3H), 3.84 (s, 3H), 4.08 (t, 2H, J = 5.5 Hz), 5.12 (d, 1H, J = 13.6 Hz), 5.41 (d, 1H, J = 13.6 Hz), 6.18 (s, 1H), 6.32 ~ 7.38 (m, 10 H).

MS (m/z): MH<sup>+</sup> (500).

10

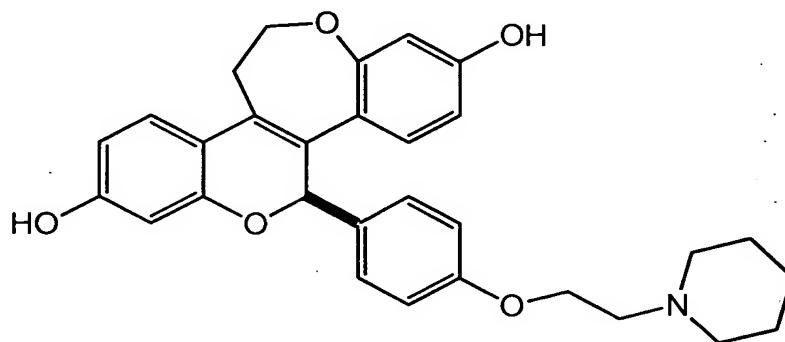
### Example 145

5R<sup>+</sup>-(+)-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol Compound #99

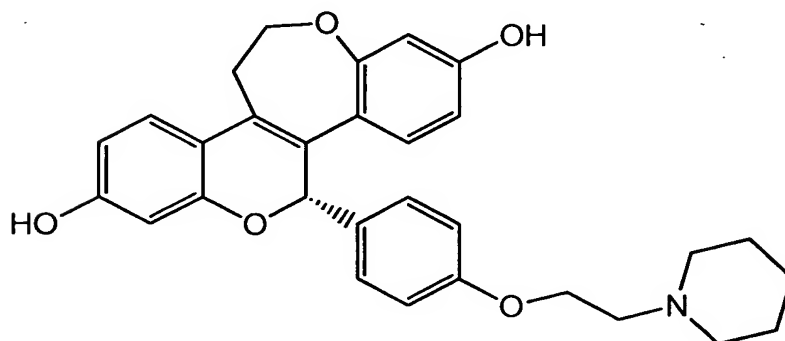
and

15

5S<sup>+</sup>-(-)-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol Compound #100



and



The racemic 5-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol compound,

20

prepared as in Example 77, (1.18 g) was loaded onto a ChiralPak AD chiral HPLC column (5 cm I.D. x 50 cm L) and eluted with 80% IPA and 20% MeOH at the 150 mL/min flow rate. The two peaks were removed under vacuum to yield the two enantiomers as follows:

- 5      Peak 1: 5R<sup>+</sup>-(+)-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol:

<sup>1</sup>H NMR (CD<sub>3</sub>OD) δ 1.46 (m, 2H), 1.59 (m, 4H), 2.55 (m, 4H), 2.72 (m, 2H), 2.81 (m, 2H), 4.02 (t, 2H, J = 5.4 Hz), 4.60 (m, 2H), 6.05 (s, 1H), 6.14 ~ 7.34 (m, 10H).

- 10      m.p. 147 ~149 °C

[α] = + 57 °, (c = 0.302, MeOH).

Anal. Calculated for C<sub>30</sub>H<sub>31</sub>NO<sub>5</sub>·0.95 H<sub>2</sub>O

C, 71.68; H, 6.60; N, 2.79;

Found: C, 71.67; H, 6.52; N, 2.57.

- 15      MS (m/z): MH<sup>+</sup> (486).

Peak 2: 5S<sup>+</sup>-(-)-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol

[α] = - 59 °, (c = 0.41, MeOH).

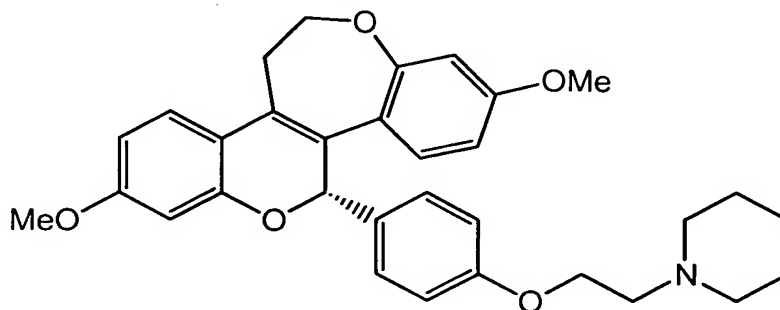
MS (m/z): MH<sup>+</sup> (486).

20

### Example 146

**5S<sup>+</sup>-(-)-1-{2-[4-(2,8-Dimethoxy-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl)-phenoxy]-ethyl}-piperidine**

#### **Compound #156**



25

5S<sup>+</sup>-(-)-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol (1 g) prepared as in

Example 145 was dissolved in CH<sub>3</sub>CN/MeOH (3:1) (28 mL). TMSCHN<sub>2</sub> (2M in hexane, 3.3 mL) and was stirred overnight. The reaction mixture was concentrated to dryness and purified on SiO<sub>2</sub> using 5% MeOH in CH<sub>2</sub>Cl<sub>2</sub> to yield the title compound as a yellow oil.

<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 1.40 (m, 2H), 1.59 (m, 4H), 2.49 (broad s, 4H), 2.72 (m, 2H), 2.91 (m, 2H), 3.71 (s, 3H), 3.78 (s, #H), 4.05 (m, 2H), 4.69 (m, 2H), 6.05 (s, 1H), 6.36 ~ 7.39 (m, 10H)

MS (m/z): MH<sup>+</sup> (514).

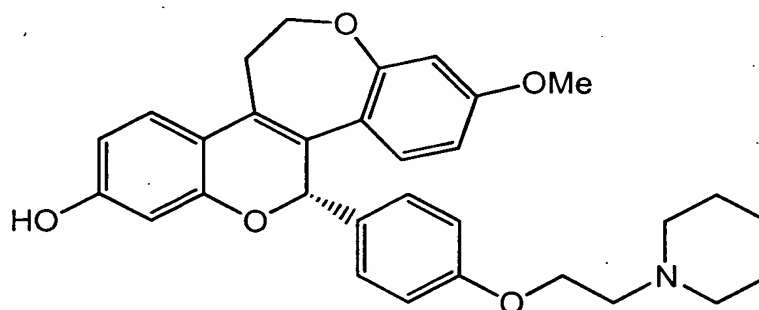
10

### Example 147

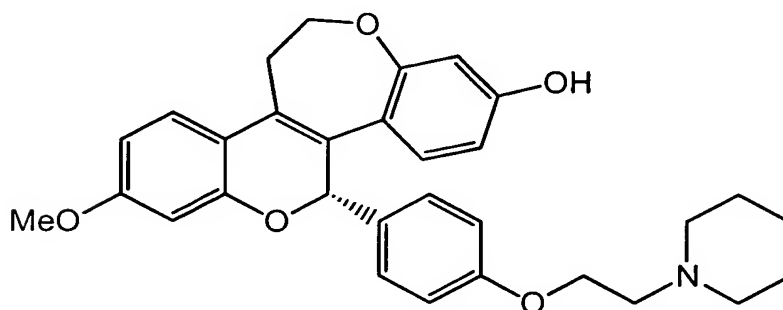
**2-Methoxy-5S\*(-)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-8-ol Compound #196**  
and

15

**8-Methoxy-5\*(-)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol Compound #195**



and



5S\*(-)-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol (10 g), prepared as in Example 145, was dissolved in CH<sub>3</sub>CN/MeOH (3:1) (280 mL). 1.1 equivalent



of TMSCHN<sub>2</sub> (2M in hexane, 10.2 mL) and was stirred overnight. The reaction mixture was concentrated to dryness and purified on SiO<sub>2</sub> using 5-10% MeOH in CH<sub>2</sub>Cl<sub>2</sub> to yield a mixture of the title compounds as yellow foam.

5

The mixture of compounds (2.9g) was loaded onto a ChiralPak AD chiral HPLC column 5 cm I.D. x 50 cm L) and eluted with 100% IPA at the 150 mL/min flow rate. The two peaks were removed under vacuum to yield the two title compounds as follows:

- 10 Peak 1: 2-Methoxy-5S\*(-)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-8-ol

<sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 1.42 (s, 2H), 1.61 (s, 4H), 2.41 ~ 3.14 (m, 8H), 3.67 (s, 3H), 4.24 (s, 2H), 4.59 (m, 2H), 6.14 ~ 7.28 (m, 11H).

MS (m/z): MH<sup>+</sup> (500).

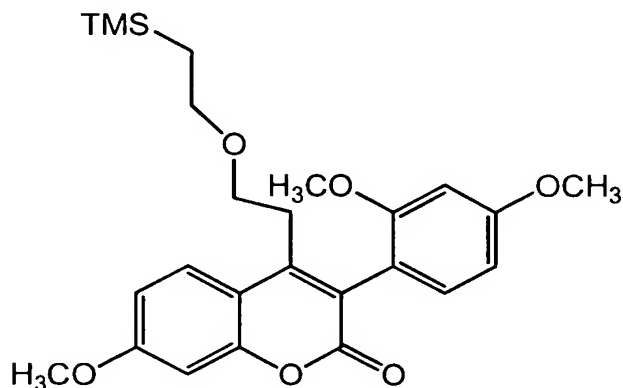
- 15 Peak 2: 8-Methoxy-5S\*(-)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol

<sup>1</sup>H NMR (CD<sub>3</sub>OD) δ 1.41 (broad s, 2H), 1.59 (broad s, 4H), 2.50 (broad s, 4H), 2.68 (m, 2H), 2.81 (m, 2H), 3.78 (m, 2H), 4.61 (t, 2H, J = 6.0 Hz), 6.02 (s, 1H), 6.22 ~ 7.29 (m, 10H).

- 20 MS (m/z): MH<sup>+</sup> (500).

### Example 148

3-(2,4-Dimethoxy-phenyl)-7-methoxy-4-[2-(2-trimethylsilanyl-ethoxy)-ethyl]-chromen-2-one Compound #258



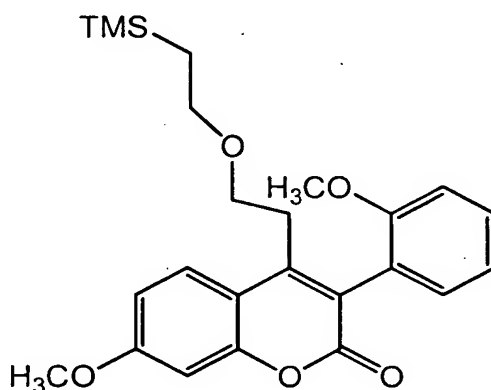
25

A 200 ml single neck flask was charged with lithium bis(trimethylsilyl)amide ((TMS)<sub>2</sub>NLi, 16 mL 1M solution in THF). 3-(2,4-dimethoxy-phenyl)-7-methoxy-4-methyl-chromen-2-one (3.45g) in anhydrous THF was added to the reaction mixture over a 10-min period and stirred at –  
5 20°C for 45 min. (2-Chloromethoxy-ethyl)-trimethyl-silane (1.95g) was added to the reaction mixture over a 10-min period and stirring was continued at – 10°C for 6 hours. The reaction mixture was quenched with saturated NH<sub>4</sub>Cl (200 mL) and extracted with EtOAc (200 mL). The organic phase was condensed *in vacuo* at 60°C to yield a crude product which was purified by  
10 flash chromatography to yield the title compound as a white solid.

MS (m/z): MH<sup>+</sup> (457), MNa<sup>+</sup> (479).

#### Example 149

15 7-Methoxy-3-(2-methoxy-phenyl)-4-[2-(2-trimethylsilyl-ethoxy)-ethyl]-chromen-2-one Compound #262

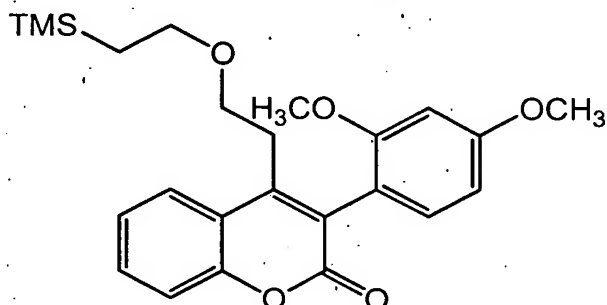


The title compound was prepared according to the procedure described in Example 148 above, substituting 3-(2,4-dimethoxy-phenyl)-7-methoxy-4-methyl-chromen-2-one with 7-methoxy-3-(2-methoxy-phenyl)-4-methyl-chromen-2-one, to yield a white solid.  
20

MS (m/z): MH<sup>+</sup> (427), MNa<sup>+</sup> (449).

**Example 150**

**3-(2,4-Dimethoxy-phenyl)-4-[2-(2-trimethylsilyl-ethoxy)-ethyl]-  
chromen-2-one Compound #259**



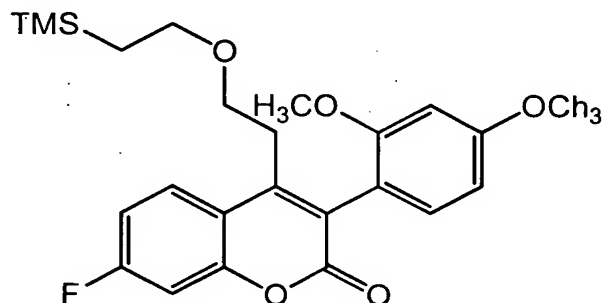
5. The title compound was prepared according to the procedure described in Example 148 above, substituting 3-(2,4-dimethoxy-phenyl)-7-methoxy-4-methyl-chromen-2-one with 3-(2,4-dimethoxy-phenyl)-4-methyl-chromen-2-one, to yield a white solid.

MS (m/z):  $MH^+$  (427),  $MNa^+$  (449).

10

**Example 151**

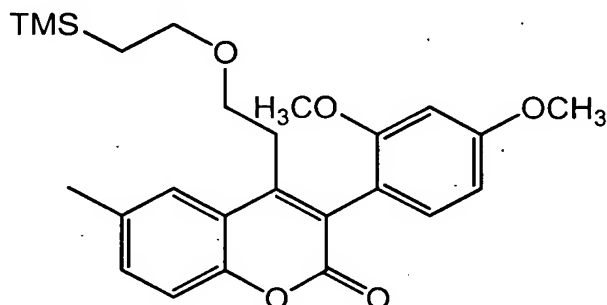
**3-(2,4-Dimethoxy-phenyl)-7-fluoro-4-[2-(2-trimethylsilyl-ethoxy)-ethyl]-  
chromen-2-one Compound #264**



15. The title compound was prepared according to the procedure described in Example A above, substituting 3-(2,4-dimethoxy-phenyl)-7-methoxy-4-methyl-chromen-2-one with 3-(2,4-dimethoxy-phenyl)-7-fluoro-4-methyl-chromen-2-one, to yield a solid.

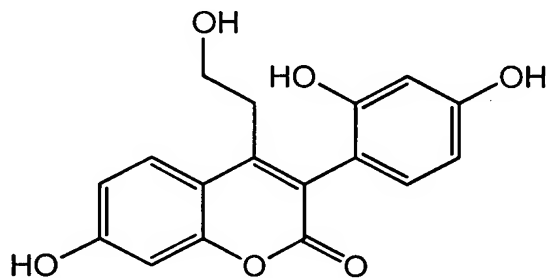
MS (m/z):  $MH^+$  (445),  $MNa^+$  (467).

20

**Example 152****3-(2,4-Dimethoxy-phenyl)-6-methyl-4-[2-(2-trimethylsilyl-ethoxy)-ethyl]-chromen-2-one Compound #267**

5 The title compound was prepared according to the procedure described in Example 148 above, substituting 3-(2,4-dimethoxy-phenyl)-7-methoxy-4-methyl-chromen-2-one with 3-(2,4-dimethoxy-phenyl)-4,6-dimethyl-chromen-2-one, to yield a solid.

MS (m/z):  $MH^+$  (441),  $MNa^+$  (463).

**Example 153****3-(2,4-Dihydroxy-phenyl)-7-hydroxy-4-(2-hydroxy-ethyl)-chromen-2-one Compound #62**

15 A 1 L flask was charged with  $CH_2Cl_2$  (200 mL) and 3-(2,4-dimethoxy-phenyl)-7-methoxy-4-[2-(2-trimethylsilyl-ethoxy)-ethyl]-chromen-2-one, prepared as in Example 148, (5g ) The solution was stirred at room temperature under  $N_2$  and  $BBr_3$  (8 mL) was added under  $N_2$  pressure over a 20-min period. The reaction mixture was then stirred for 36 hours. The  
20 reaction mixture was cooled to  $0^\circ C$ , and the reaction mixture was poured in precooled 1N NaOH (200 ml,  $5^\circ C$ ). The resulting solution was neutralized by 1N HCl to pH 4 and was extracted by EtOAc (2 L). The organic layer was

separated and concentrated on vacuum to dryness, then purified by flash chromatography to yield the title compound as a yellow solid.

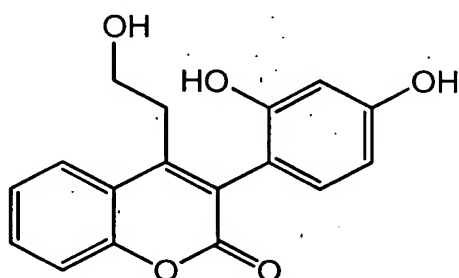
MS (m/z):  $MH^+$  (315),  $MNa^+$  (337).

5

**Example 154**

**3-(2,4-Dihydroxy-phenyl)-4-(2-hydroxy-ethyl)-chromen-2-one Compound**

**#269**



10 The title compound was prepared according to the procedure described in Example 153 above, substituting 3-(2,4-dimethoxy-phenyl)-7-methoxy-4-[2-(2-trimethylsilyl-ethoxy)-ethyl]-chromen-2-one with 3-(2,4-Dimethoxy-phenyl)-4-[2-(2-trimethylsilyl-ethoxy)-ethyl]-chromen-2-one, prepared as in Example 150, to yield a solid.

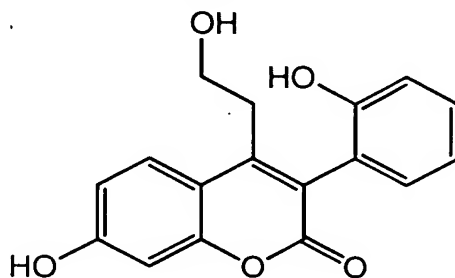
MS (m/z):  $MH^+$  (299),  $MNa^+$  (321).

15

**Example 155**

**7-Hydroxy-4-(2-hydroxy-ethyl)-3-(2-hydroxy-phenyl)-chromen-2-one**

**Compound #271**



20 The title compound was prepared according to the procedure described in Example 153 above, substituting 3-(2,4-dimethoxy-phenyl)-7-methoxy-4-[2-(2-trimethylsilyl-ethoxy)-ethyl]-chromen-2-one with 7-

methoxy-3-(2-methoxy-phenyl)-4-[2-(2-trimethylsilanyl-ethoxy)-ethyl]-chromen-2-one, prepared as in Example 149, to yield a solid.

MS (m/z):  $MH^+$  (299),  $MNa^+$  (321).

5

**Example 156**

**3-(2,4-Dihydroxy-phenyl)-7-fluoro-4-(2-hydroxy-ethyl)-chromen-2-one  
Compound #270**

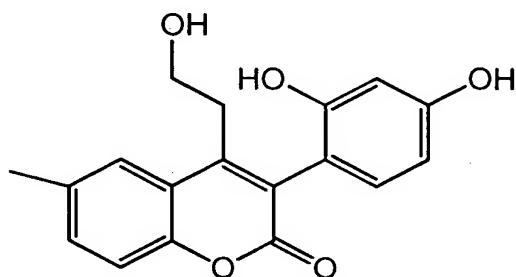
The title compound was prepared according to the procedure described in Example 153 above, substituting 3-(2,4-dimethoxy-phenyl)-7-methoxy-4-[2-(2-trimethylsilanyl-ethoxy)-ethyl]-chromen-2-one with 3-(2,4-dimethoxy-phenyl)-7-fluoro-4-[2-(2-trimethylsilanyl-ethoxy)-ethyl]-chromen-2-one, prepared as in Example 151, to yield a solid.

MS (m/z):  $MH^+$  (317),  $MNa^+$  (339).

15

**Example 157**

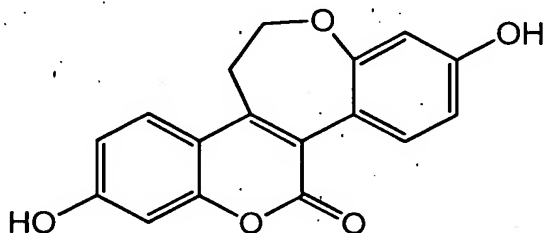
**3-(2,4-Dihydroxy-phenyl)-4-(2-hydroxy-ethyl)-6-methyl-chromen-2-one  
Compound #268**



The title compound was prepared according to the procedure described in Example 153 above, substituting 3-(2,4-dimethoxy-phenyl)-7-methoxy-4-[2-(2-trimethylsilanyl-ethoxy)-ethyl]-chromen-2-one with 3-(2,4-dimethoxy-phenyl)-6-methyl-4-[2-(2-trimethylsilanyl-ethoxy)-ethyl]-chromen-2-one, prepared as in Example 152, to yield a solid.

MS (m/z):  $MH^+$  (313),  $MNa^+$  (335).

25

**Example 158****2,8-Dihydroxy-11,12-dihydro-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-one Compound #56**

5           A suspension of 3-(2,4-Dihydroxy-phenyl)-7-hydroxy-4-(2-hydroxy-ethyl)-chromen-2-one, prepared as in Example 153, (2.5g) and anhydrous THF (40 mL) was cooled to about  $-5$  to  $0^{\circ}\text{C}$ . To the reaction mixture was then added diisopropyl azodicarboxylate (DIAD, 6.64.5 mL) over a 35-min period and the mixture stirred at  $-5^{\circ}\text{C}$  for 30 min. A solution of

10   triphenylphosphine (8.41g) in THF (160 ml) was then added over a 30-min period, the reaction was warmed to  $20^{\circ}\text{C}$  and stirred for 18 hours. The solvent was condensed *in vacuo* at  $60^{\circ}\text{C}$  and the resulting residue was dissolved in  $\text{CH}_2\text{Cl}_2$  (300 mL) and washed with 2 *N* NaOH solutions three times (200, mL, 100mL and 50mL). The aqueous phases were combined and

15   back-extracted with  $\text{CH}_2\text{Cl}_2$  (50 ml). The aqueous phase was cooled to  $0^{\circ}\text{C}$  and acidified to pH  $\sim 1$ -2 with concentrated HCl solution (37%), and the resulting slurry was stirred at  $10^{\circ}\text{C}$  for 1 hour. The solid was isolated by filtration and the filter cake was washed with  $\text{H}_2\text{O}$  (50 mL ). This solid was dried in a vacuum over to yield the title compound as a solid.

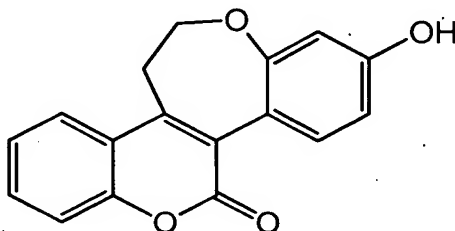
20           MS: 295.0 M-H; 297 M+H; 319 M+Na

$^1\text{H}$ -NMR (300 MHz, THF- $d_8$ ):  $\delta$  (ppm) 6.5-7.8 (m, 6H), 4.6 (t, 2H), 3.0 (t, 2H).

25

**Example 159**

**2-Hydroxy-11,12-dihydro-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-one Compound #225**

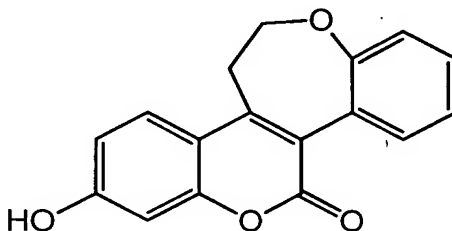


5 The title compound was prepared according to the procedure described in Example 153 above, substituting 3-(2,4-dihydroxy-phenyl)-7-hydroxy-4-(2-hydroxy-ethyl)-chromen-2-one, with 3-(2,4-Dihydroxy-phenyl)-4-(2-hydroxy-ethyl)-chromen-2-one, prepared as in Example 158, to yield a solid.

10 MS(m/z): M+H= 281, M+Na= 283

**Example 160**

**8-Hydroxy-11,12-dihydro-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-one Compound #223**



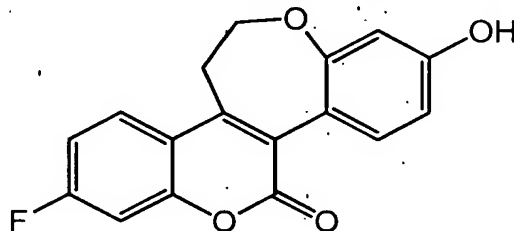
15 The title compound was prepared according to the procedure described in Example 153 above, substituting 3-(2,4-dihydroxy-phenyl)-7-hydroxy-4-(2-hydroxy-ethyl)-chromen-2-one, with 7-hydroxy-4-(2-hydroxy-ethyl)-3-(2-hydroxy-phenyl)-chromen-2-one, prepared as in Example 158, to  
20 yield a solid.

MS(m/z): M+H= 281, M+Na= 283.



**Example 161**

**8-Fluoro-2-hydroxy-11,12-dihydro-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-one Compound #226**

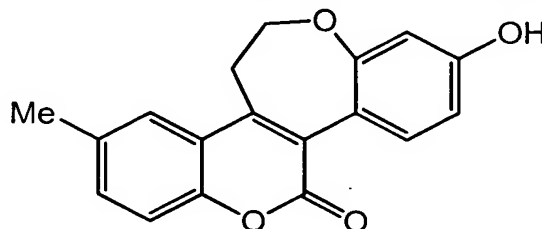


5 The title compound was prepared according to the procedure described in Example 153 above, substituting 3-(2,4-dihydroxy-phenyl)-7-hydroxy-4-(2-hydroxy-ethyl)-chromen-2-one, with 3-(2,4-Dihydroxy-phenyl)-7-fluoro-4-(2-hydroxy-ethyl)-chromen-2-one, prepared as in Example 158, to yield a solid.

10 MS(m/z): M+H= 299, M+Na= 321.

**Example 162**

**2-Hydroxy-9-methyl-11,12-dihydro-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-one Compound #287**



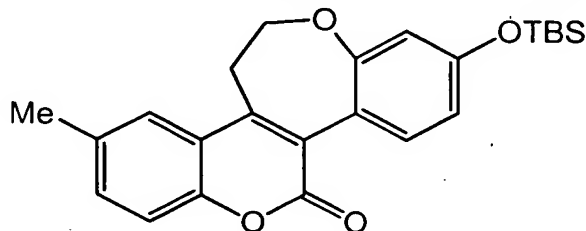
15 The title compound was prepared according to the procedure described in Example 153 above, substituting 3-(2,4-dihydroxy-phenyl)-7-hydroxy-4-(2-hydroxy-ethyl)-chromen-2-one, with 2-Hydroxy-9-methyl-11,12-dihydro-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-one, prepared as in Example 158, to yield a solid.

20 as in Example 158, to yield a solid.

MS(m/z): M+H= 295, M+Na= 317.

**Example 163**

**2-(tert-Butyl-dimethyl-silyloxy)-9-methyl-11,12-dihydro-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-one Compound #228**

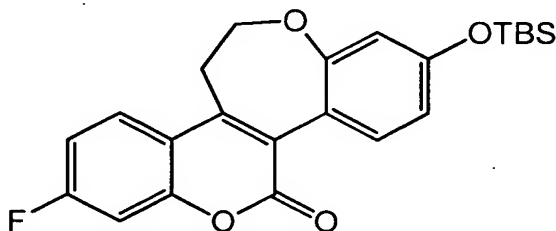


The title compound was prepared according to the procedure described in Example 22, substituting 2-hydroxy-9-methyl-11,12-dihydro-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-one for 2, 8-dihydroxy-11H-chromeno[4,3-c]chromen-5-one, to yield a solid.

MS(m/z): M+H= 409, M+Na= 431

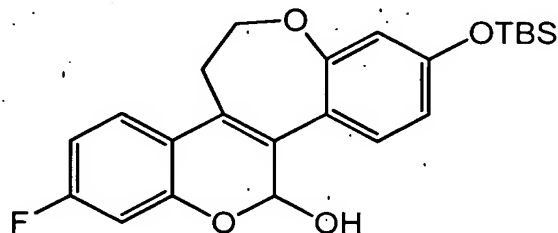
**Example 164**

**2-(tert-Butyl-dimethyl-silyloxy)-8-fluoro-11,12-dihydro-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-one Compound #288**



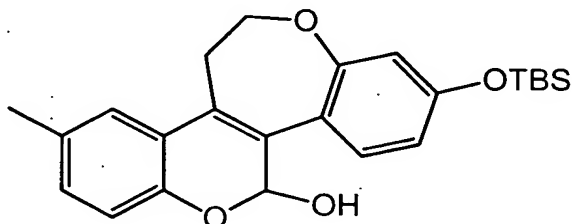
The title compound was prepared according to the procedure described in Example 22, substituting 8-fluoro-2-hydroxy-11,12-dihydro-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-one for 2, 8-dihydroxy-11H-chromeno[4,3-c]chromen-5-one, to yield a solid.

MS(m/z): M+H= 413, M+Na= 435.

**Example 165****2-(tert-Butyl-dimethyl-silyloxy)-8-fluoro-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol Compound #205**

5 The title compound was prepared according to the procedure described in Example 84, substituting 2-(tert-butyl-dimethyl-silyloxy)-8-fluoro-11,12-dihydro-6,13-dioxabenzo[3,4]cyclohepta[1,2-a] naphthalen-5-one for 2,6,12-tris[[(1,1-dimethylethyl)dimethylsilyl]oxy]-2,3-dihydro-[1]benzopyrano[4,3-e][1]benzoxocin-9(1*H*)-one, to yield a yellow solid.

10 MS(m/z): M+H= 415, M+Na= 437.

**Example 166****2-(tert-Butyl-dimethyl-silyloxy)-9-methyl-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol Compound #207**

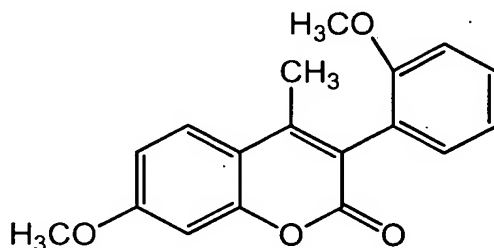
15 The title compound was prepared according to the procedure described in Example 84, substituting 2-(tert-butyl-dimethyl-silyloxy)-9-methyl-11,12-dihydro-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]-naphthalen-5-one for 2,6,12-tris[[(1,1-dimethylethyl)dimethylsilyl]oxy]-2,3-dihydro-[1]benzopyrano[4,3-e][1]benzoxocin-9(1*H*)-one, to yield a yellow solid.

20 MS(m/z): M+H= 411, M+Na= 433.

**Example 167**

**7-Methoxy-3-(2-methoxy-phenyl)-4-methyl-chromen-2-one Compound**

**#289**

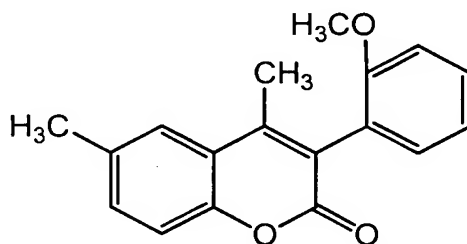


5        The title compound was prepared according to the procedure described in Example 1, substituting commercially available 2,4-dimethoxy acetophenone and 2-methoxy phenyl acetic acid for 2,4-dihydroxyacetophenone and 4-dimethoxy phenyl acetic acid, respectively, to yield a yellow solid.

10        MS(m/z): M+H= 297, M+Na= 319.

**Example 168**

**3-(2-Methoxy-phenyl)-4,6-dimethyl-chromen-2-one Compound #290**



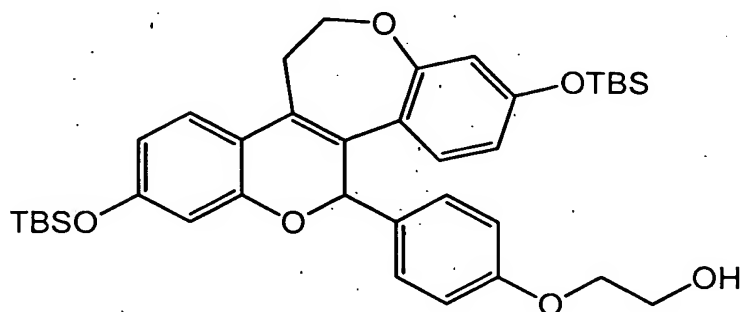
15        The title compound was prepared according to the procedure described in Example 1, substituting 4-methyl-2-hydroxy-acetophenone and 2,4-dimethoxy phenyl acetic acid for 2,4-dihydroxyacetophenone and 4-dimethoxy phenyl acetic acid, respectively, to yield a yellow solid.

MS(m/z): M+H= 281, M+Na= 303.

20

**Example 169**

**2-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl]-phenoxy}-ethanol**

**Compound #186**

5

To a clear solution of 2-(4-iodo-phenoxy)-ethanol (400 mg, 5 eq.) in THF (10 mL) was added isopropyl magnesium bromide (3.0 mL, ~1.0 M, 10 eq.). After 10 min, 2,8-bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-ol (example 75) (162 mg, 0.30 mmol) in THF (2 mL) was added at 25°C and stirred for 30 min before the reaction mixture was quenched with NH<sub>4</sub>Cl aqueous saturated solution. After quenching, EtOAc (200 mL) was added, the organic layer was separated and dried over anhydrous Na<sub>2</sub>SO<sub>4</sub> and concentrated under reduced pressure yield a crude oil. The crude oil was dissolved in toluene (10 mL) and then treated with TFA (0.023 mL, 1 eq.) at 0°C. The reaction mixture was then diluted by EtOAc (200 mL) and washed with water (200 mL). The organic layer was separated and dried over Na<sub>2</sub>SO<sub>4</sub>, then concentrated under reduced pressure to yield a crude oil. This crude oil was purified by flash column chromatography to yield the title compound as a foam.

<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 7.35 – 6.29 (m, 10 H), 6.02 (s, 1H), 4.62 (t, 2H, J = 6.5 Hz), 4.01 – 3.83 (m, 4H), 2.86 (m, 2H), 0.93 (d, 18H, J = 13.7 Hz), 0.17 (d, 12H, J = 15.2 Hz).

MS (m/z): MH<sup>+</sup> (647), MNa<sup>+</sup> (669)

The racemic 2-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxabenzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl]-phenoxy}-ethanol product (950 mg) was loaded on to ChiralPak AD chiral HPLC column ( 5 cm

I.D. x 50 cm L) and eluted with 50% IPA and 50% Hexanes at the 150 mL/min flow rate. The two peaks were removed under vacuum to yield the two enantiomers as follows:

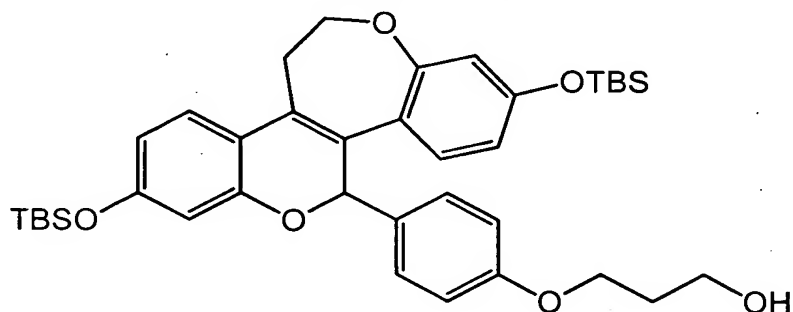
Peak 1: 5R<sup>+</sup>-(+)-2-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl]-phenoxy}-ethanol  
 $[\alpha]^{20}_D = +33.5^\circ$  (c 0.30, CHCl<sub>3</sub>).

Peak 2: 5S<sup>-</sup>-(-)-2-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl]-phenoxy}-ethanol  
 $[\alpha]^{20}_D = -33.5^\circ$  (c 0.36, CHCl<sub>3</sub>).

### Example 170

3-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl]-phenoxy}-propan-1-ol

#### Compound #191



Following the same procedure described in Example 169, substituting 2-(4-iodo-phenoxy)-ethanol with 3-(4-iodo-phenoxy)-propan-1-ol (2.78 g, 10 mmol, 5 eq.), to yield the title compound as a white solid.

Anal. Calculated for C<sub>38</sub>H<sub>52</sub>O<sub>6</sub>Si<sub>2</sub>: C, 69.05; H, 7.93, Si, 8.50.

Found: C, 68.68; H, 8.00, Si, 8.90.

<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 7.19 – 6.35 (m, 10H), 5.63 (s, 1H), 4.49 (t, 2H, J = 6.6Hz), 3.99 (m, 2H), 3.66 (m, 2H), 2.42 (m, 2H), 1.93 (m, 2H), 0.94 (d, 18H, J = 13.7 Hz), 0.16 (d, 12H, J = 15.2 Hz).

MS (m/z): MH<sup>+</sup> (661).

The racemic 3-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl]-phenoxy}-propan-

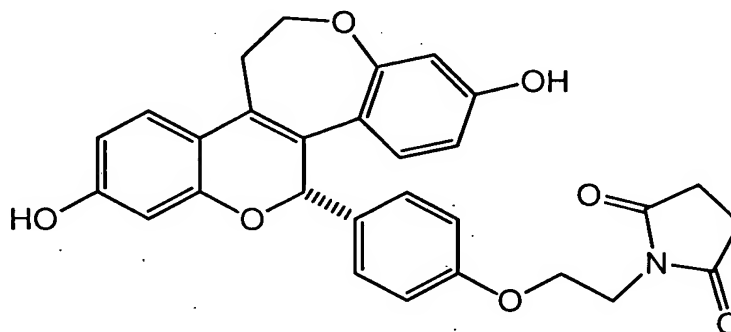
1-ol product (850 mg) was loaded on to ChiralPak AD chiral HPLC column ( 5 cm I.D. x 50 cm L) and eluted with 50% IPA and 50% Hexanes at the 150 mL/min flow rate. The two peaks were removed under vacuum to yield the two enantiomers as follows:

5 Peak 1: 5R<sup>+</sup>-(+)-3-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl]-phenoxy}-propan-1-ol  
 $[\alpha]_D^{20} = 29.5^\circ$  (c 0.36, CHCl<sub>3</sub>).

Peak 2: 5S<sup>+</sup>-(-)-3-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl]-phenoxy}-propan-1-ol  
 10  $[\alpha]_D^{20} = -29.5^\circ$  (c 0.36, CHCl<sub>3</sub>).

### Example 171

5S<sup>+</sup>-(+)-1-{2-[4-(2,8-Dihydroxy-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl)-phenoxy]-ethyl}-pyrrolidine-  
 15 2,5-dione Compound #277



Step A:

To the solution of 5S<sup>+</sup>-(-)-2-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl]-phenoxy}-ethanol ( 323 mg, 0.5 mmo), prepared as in Example 169 and  
 20 succinamide (49.5 mg) in CH<sub>2</sub>Cl<sub>2</sub> (5ml) was added triphenylphosphene(132mg) and DEAD (0.8 ml) and the reaction mixture stirred for 12 hours. The reaction mixture was then quenched by adding 50 ml of water and diluted with ETOAc (100ml). The organic layer was separated  
 25 and dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>. The compound was purified by flash chromatography to yield 1-(2-{4-[2,8-bis-(tert-butyl-dimethyl-silyloxy)-11,12-

dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalene-5-yl]-phenoxy}-ethyl)-pyrrolidine-2,5-dione as a solid.

MS (m/z): MH<sup>+</sup> (729). ): M-H (727)

$[\alpha]_D^{20} = -35.5^\circ$  (c 0.36, CHCl<sub>3</sub>).

5 Step B:

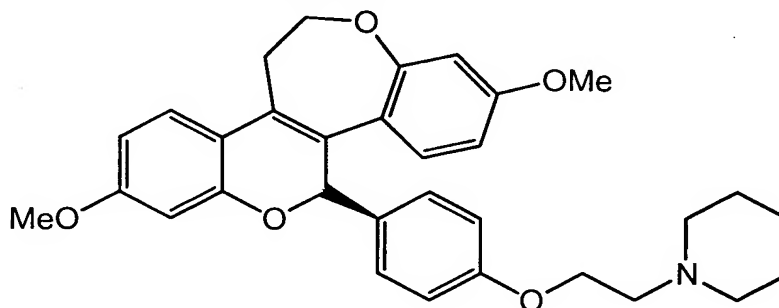
1-(2-{4-[2,8-Bis-(tert-butyl-dimethyl-silyloxy)-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl]-phenoxy}-ethyl)-pyrrolidine-2,5-dione, prepared as in Step A above, (220 mg) was dissolved in acetonitrile:pyridine (10:1). HF•Pyridine (0.5 ml) was added and the reaction mixture was stirred for 12 hours room temperature. The reaction mixture was quenched by aqueous saturated solution of NaHCO<sub>3</sub> (100 mL) and then diluted by ethyl acetate (200 mL). The organic layer was separated and then concentrated under reduced pressure to yield a crude oil. The crude oil was purified by flash chromatography to yield the title compound as a solid.

15 MS (m/z): MH<sup>+</sup> (500). ): M-H (498).

**Example 177**

5R<sup>+</sup>-(+)-1-{2-[4-(2,8-Dimethoxy-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-5-yl)-phenoxy]-ethyl}-piperidine

**Compound 300**



25 5R<sup>+</sup>-(+)-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol (10 g) as prepared in Example 145 was dissolved in CH<sub>3</sub>CN/MeOH (3:1) (340 mL). TMSCHN<sub>2</sub> (2M in hexane, 30.3 mL) and was stirred 36 h. The reaction mixture was



concentrated to dryness and purified on SiO<sub>2</sub> using 5% MeOH in CH<sub>2</sub>Cl<sub>2</sub> to yield the title compound as a yellow foam.

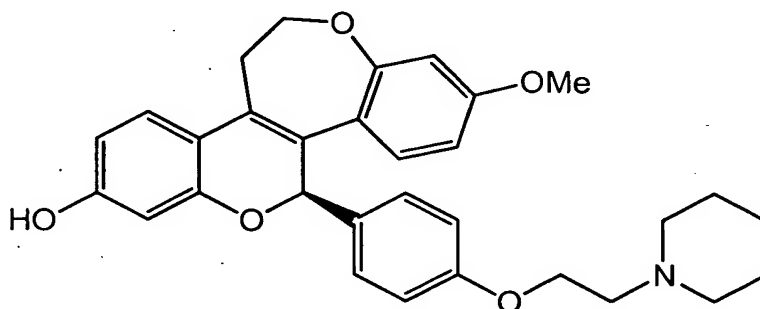
<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 1.40 (m, 2H), 1.59 (m, 4H), 2.49 (broad s, 4H), 2.72 (m, 2H), 2.91 (m, 2H), 3.71 (s, 3H), 3.78 (s, #H), 4.05 (m, 2H), 4.69 (m, 2H), 6.05 (s, 1H), 6.36 ~ 7.39 (m, 10H). [α] = +7.2 (c = 0.38 g/100 mL, CHCl<sub>3</sub>, 25 °C). MS (m/z): MH<sup>+</sup> (514).

### Example 178

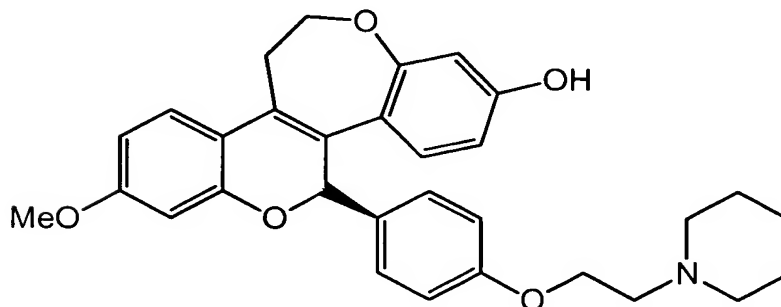
2-Methoxy-5R<sup>+</sup>-(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-8-ol  
Compound 301

and

8-Methoxy-5R<sup>+</sup>-(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol  
Compound 302



and



5R<sup>+</sup>-(+)-[4-(2-Piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalene-2,8-diol (10 g) prepared as in

Example 145, was dissolved in CH<sub>3</sub>CN/MeOH (3:1) (286 mL). 1.1 equivalent of TMSCHN<sub>2</sub> (2M in hexane, 10.2 mL) and was stirred overnight. The reaction mixture was concentrated to dryness and purified on SiO<sub>2</sub> using 5-10% MeOH in CH<sub>2</sub>Cl<sub>2</sub>. to yield a mixture of the title compounds as yellow foam.

The mixture of compounds (250 mg) was loaded onto a ChiralPak AD chiral HPLC column (5 cm I.D. x 50 cm L) and eluted with 15% IPA in hexanes at the 100 mL/min flow rate. The two peaks were removed under vacuum to yield the two title compounds as follows:

10 Peak 1: 2-Methoxy-5R\*-(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-8-ol

<sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 1.42 (s, 2H), 1.61 (s, 4H), 2.41 ~ 3.14 (m, 8H), 3.67 (s, 3H), 4.24 (s, 2H), 4.59 (m, 2H), 6.14 ~ 7.28 (m, 11H). MS (m/z): MH<sup>+</sup> (500).

15 Peak 2: 8-Methoxy-5R\*-(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-11,12-dihydro-5H-6,13-dioxo-benzo[3,4]cyclohepta[1,2-a]naphthalen-2-ol

<sup>1</sup>H NMR (CD<sub>3</sub>OD) δ 1.41 (broad s, 2H), 1.59 (broad s, 4H), 2.50 (broad s, 4H), 2.68 (m, 2H), 2.81 (m, 2H), 3.78 (m, 2H), 4.61 (t, 2H, J = 6.0 Hz), 6.02 (s, 1H), 6.22 ~ 7.29 (m, 10H). MS (m/z): MH<sup>+</sup> (500).

20

### Example 179

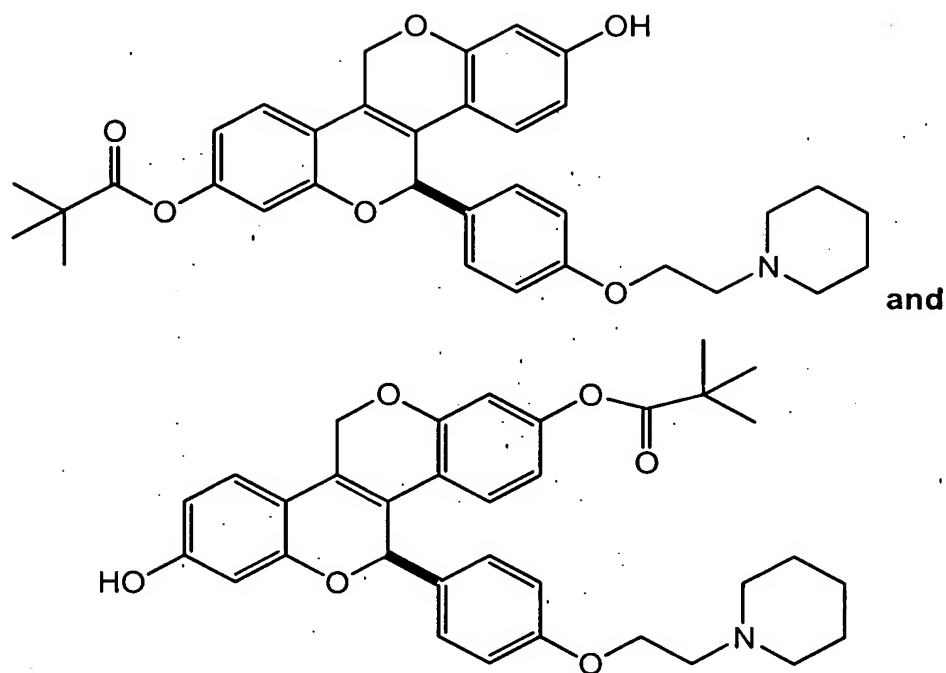
**2,2-Dimethyl-propionic acid 8-hydroxy-11R\*(-)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester**

**Compound 92**

25

and

**2,2-Dimethyl-propionic acid 8-hydroxy-5R\*(-)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester Compound 91**



Dimethyl-propionic acid 8-(2,2-dimethyl-propionyloxy)-5R\*-(+)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester, prepared as in Example 67, (11 g) was suspended in MeOH (220 mL) and 1.2 equivalents of diethylamine were added into a sealed tube. The resulting solution was heated to 150°C for 3 h. The reaction mixture was concentrated on vacuum and purified on SiO<sub>2</sub> to yield a mixture of

The mixture (410 mg) was loaded onto a ChiralPak AD chiral HPLC column (5 cm I.D. x 50 cm L) and eluted with 20% IPA in hexanes at the 100 mL/min flow rate. The two peaks were removed under vacuum to yield the two regio-isomers as follow:

Peak 1: 2,2-Dimethyl-propionic acid 8-hydroxy-5R\*(-)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester

<sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 1.35 (s, 9H), 1.45 (broad s, 2H), 1.62 (broad s, 4H), 2.61 (broad s, 4H), 2.82 (broad s, 2H), 3.92 (t, 2H, J = 6.0 Hz), 5.05 (d, 1H, J = 14.7 Hz), 5.25 (d, 1H, J = 14.7 Hz), 6.12 ~ 7.22 (m, 11H)

MS (m/z): MH<sup>+</sup> (556).

Peak 2: 2,2-Dimethyl-propionic acid 8-hydroxy-11R\*(-)-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,11-dihydro-chromeno[4,3-c]chromen-2-yl ester

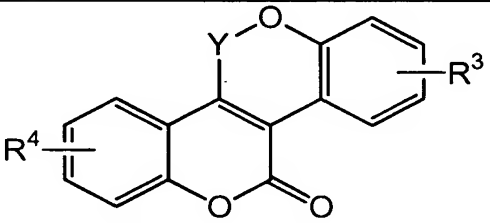
$^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  1.19 (d, 9H,  $J = 7.0$  Hz), 1.42 (broad s, 2H), 1.61 (broad s, 4H), 2.59 (broad s, 4H), 2.72 (broad s, 2H), 4.06 (m, 2H), 5.05 (d, 1H,  $J = 13.2$  Hz), 5.24 (d, 1H,  $J = 13.2$  Hz), 6.16 ~ 7.23 (m, 11H)  
MS ( $m/z$ ):  $\text{MH}^+$  (556).

5

Following the procedures described in the Schemes and Examples above, representative compounds of the present invention were prepared, as listed in Tables 1-3. For the stereo-configuration of the  $\text{R}^2$  group, the  $\text{R}^*$  and  $\text{S}^*$  notations indicate that the exact orientation was not determined.

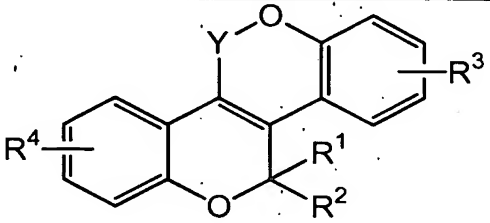
10

TABLE 1

				
ID No	Y	$\text{R}^3$	$\text{R}^4$	Calc. MW.
1	$-\text{CH}_2-$	2-hydroxy	8-hydroxy	282.25
2	$-\text{CH}_2-$	2-methoxy	8-methoxy	310.30
3	$-\text{CH}_2-$	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	510.78
7	$\text{C}(\text{O})$	2-methoxy	8-methoxy	324.29
37	$-\text{CH}_2-$	2-hydroxy	8-fluoro	284.24
84	$-\text{CH}_2-$	2-hydroxy	7-hydroxy	282.25
85	$-\text{CH}_2-$	2-(t-butyl dimethyl-silyloxy)	8-fluoro	398.50
88	$-\text{CH}_2-$	-	8-t-butyl-dimethyl-silyloxy	380.52
272	$-\text{CH}_2-$	2-methoxy	8-methoxy	310.31

The symbol " – " indicates that no R<sup>3</sup> substituent was present.

TABLE 2

						
ID No	Y	R <sup>1</sup>	R <sup>2</sup>	R <sup>3</sup>	R <sup>4</sup>	Calc. MW
4	-CH <sub>2</sub> -	H	hydroxy	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	512.79
5	-CH <sub>2</sub> -	H	phenyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	572.89
6	-CH <sub>2</sub> -	H	phenyl	2-hydroxy	8-hydroxy	344.36
8	-CH <sub>2</sub> -	H	4-(1-piperidinyl-ethoxy)-phenyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	700.08
9	-CH <sub>2</sub> -	H	4-(1-piperidinyl-ethoxy)-phenyl	2-hydroxy	8-hydroxy	471.55
10	-CH <sub>2</sub> -	H	4-(1-pyrrolidinyl-ethoxy)-phenyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	686.05
11	-CH <sub>2</sub> -	H	4-(1-pyrrolidinyl-ethoxy)-phenyl	2-hydroxy	8-hydroxy	457.52
12	-CH <sub>2</sub> -	H	4-(4-morpholinyl-ethoxy)-phenyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	702.05
13	-CH <sub>2</sub> -	H	4-(4-morpholinyl-ethoxy)-phenyl	2-hydroxy	8-hydroxy	473.52

14	-CH <sub>2</sub> -	H	R*(-)-[4-(1-piperidinyl-ethoxy)-phenyl]	2-hydroxy	8-hydroxy	471.55
15	-CH <sub>2</sub> -	H	S*(+)-[4-(1-piperidinyl-ethoxy)-phenyl]	2-hydroxy	8-hydroxy	471.55
16	-CH <sub>2</sub> -	H	4-(1-azepanyl-ethoxy)-phenyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	714.10
17	-CH <sub>2</sub> -	H	4-(1-azepanyl-ethoxy)-phenyl	2-hydroxy	8-hydroxy	485.58
18	-CH <sub>2</sub> -	H	4-(diethylamino-ethoxy)-phenyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	688.06
19	-CH <sub>2</sub> -	H	4-(diethylamino-ethoxy)-phenyl	2-hydroxy	8-hydroxy	459.54
20	-CH <sub>2</sub> -	H	4-(dimethylamino-ethoxy)-phenyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	660.01
21	-CH <sub>2</sub> -	H	4-(dimethylamino-ethoxy)-phenyl	2-hydroxy	8-hydroxy	431.49
22	-CH <sub>2</sub> -	H	4-(1-piperidinyl-ethoxy)-phenyl	2-t-butyl-C(O)O-	8-t-butyl-C(O)O-	639.78
23	-CH <sub>2</sub> -	H	4-(dimethyl amino)-phenyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	615.96
24	-CH <sub>2</sub> -	H	R*(-)-[4-(1-piperidinyl-ethoxy)-phenyl]	2-t-butyl-C(O)O-	8-t-butyl-C(O)O-	639.78
25	-CH <sub>2</sub> -	H	S*(+)-[4-(1-piperidinyl-ethoxy)-phenyl]	2-t-butyl-C(O)O-	8-t-butyl-C(O)O-	639.78

26	-CH <sub>2</sub> -	H	4-(dimethyl amino)-phenyl	2-hydroxy	8-hydroxy	387.43
27	-CH (OCH <sub>3</sub> )-	H	4-(1-piperidinyl-ethoxy)-phenyl	2-t-butyl- C(O)O-	8-t-butyl- C(O)O-	669.81
28	-CH(OH)-	H	4-(1-piperidinyl-ethoxy)-phenyl	2-t-butyl- C(O)O-	8-t-butyl- C(O)O-	655.78
29	-CH <sub>2</sub> -	CH <sub>3</sub>	4-(1-piperidinyl-ethoxy)-phenyl	2-hydroxy	8-hydroxy	485.58
30	-CH <sub>2</sub> -	CH <sub>3</sub>	4-(pyrrolidinyl-ethoxy)-phenyl	2-t-butyl- C(O)O-	8-t-butyl- C(O)O-	639.78
31	-CH <sub>2</sub> -	CH <sub>3</sub>	4-(pyrrolidinyl-ethoxy)-phenyl	2-hydroxy	8-hydroxy	471.55
32	-CH <sub>2</sub> -	CH <sub>3</sub>	4-(pyrrolidinyl-ethoxy)-phenyl	2-t-butyl- dimethyl silyloxy	8-(t-butyl- dimethyl- silyloxy)	700.08
33	-CH <sub>2</sub> -	CH <sub>3</sub>	4-(azepanyl-ethoxy)-phenyl	2-t-butyl- C(O)O-	8-t-butyl- C(O)O-	667.84
34	-CH <sub>2</sub> -	CH <sub>3</sub>	4-(azepanyl-ethoxy)-phenyl	2-hydroxy	8-hydroxy	499.60
35	-CH <sub>2</sub> -	CH <sub>3</sub>	4-(azepanyl-ethoxy)-phenyl	2-t-butyl- dimethyl silyloxy	8-(t-butyl- dimethyl- silyloxy)	728.13
36	-CH <sub>2</sub> -	OH	4-benzyloxy-phenyl	2-t-butyl- dimethyl silyloxy	8-(t-butyl- dimethyl- silyloxy)	695.01
38	-CH <sub>2</sub> -	CH <sub>3</sub>	3-(1-piperidinyl-n-ethoxy)-phenyl	2-t-butyl- C(O)O-	8-t-butyl- C(O)O-	653.81

39	-CH <sub>2</sub> -	CH <sub>3</sub>	3-(1-piperidinyl- n-ethoxy)- phenyl	2-hydroxy	8-hydroxy	485.58
40	-CH <sub>2</sub> -	CH <sub>3</sub>	3-(1-piperidinyl- n-ethoxy)- phenyl	2-t-butyl- dimethyl- silyloxy	8-(t-butyl- dimethyl- silyloxy)	714.10
41	-CH <sub>2</sub> -	CH <sub>3</sub>	4-(1-piperidinyl- n-ethoxy)- phenyl	2-t-butyl- C(O)O-	8-t-butyl- C(O)O-	653.81
42	-CH <sub>2</sub> -	CH <sub>3</sub>	4-(1-piperidinyl- n-ethoxy)- phenyl	2-t-butyl- dimethyl- silyloxy	8-(t-butyl- dimethyl- silyloxy)	714.10
43	-CH <sub>2</sub> -	CH <sub>3</sub>	4-(1-piperidinyl- n-ethoxy)- phenyl	2-t-butyl- C(O)O-	8-t-butyl- C(O)O-	667.84
44	-CH <sub>2</sub> -	CH <sub>3</sub>	4-(1-piperidinyl- n-propoxy)- phenyl	2-hydroxy	8-hydroxy	499.60
45	-CH <sub>2</sub> -	CH <sub>3</sub>	4-(1-piperidinyl- n-propoxy)- phenyl	2-t-butyl- dimethyl- silyloxy	8-(t-butyl- dimethyl- silyloxy)	728.13
46	-CH <sub>2</sub> -	H	4-(1-piperidinyl- n-ethoxy)- phenyl	2-hydroxy	8-fluoro	473.54
47	-CH-(iso- propyl)-	H	4-(1-piperidinyl- n-ethoxy)- phenyl	2-hydroxy	8-fluoro	515.62
48	-CH <sub>2</sub> -	H	4-(1-piperidinyl- ethoxy)-phenyl	2-OC(O) CH- (phenyl)- OC(O)CH <sub>3</sub>	8-OC(O)- CH- (phenyl)- OC(O)CH <sub>3</sub>	823.3
49	-CH <sub>2</sub> -	H	S - 4-(1- piperidinyl- ethoxy)-phenyl	2-OC(O)- 1,7,7- trimethyl- 2-oxabi- cyclo[2.2.1] ]heptan-3- one	8-OC(O)- 1,7,7- trimethyl-2- oxabicyclo [2.2.1]hepta n-3-one	831.36



50	-CH <sub>2</sub> -	H	4-(1-piperidinyl-ethoxy)-phenyl	2-OC(O)-C(CH <sub>3</sub> )(CF <sub>3</sub> )-phenyl	8-OC(O)-C(CH <sub>3</sub> )(CF <sub>3</sub> )-phenyl	903.28
51	-CH <sub>2</sub> -	H	4-(1-piperidinyl-ethoxy)-phenyl	2-OC(O)-t-butyl	8-hydroxy	55.26
52	-CH <sub>2</sub> -	H	4-(1-piperidinyl-ethoxy)-phenyl	2-hydroxy	8-OC(O)-t-butyl	555.26
53	-CH <sub>2</sub> CH <sub>2</sub> -	H	hydroxy	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	526.26
54	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(1-piperidinyl-ethoxy)-phenyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	713.39
55	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(1-piperidinyl-ethoxy)-phenyl	2-hydroxy	8-hydroxy	485.22
86	-CH <sub>2</sub> -	H	hydroxy	2-(t-butyl-dimethyl-silyloxy)	8-fluoro	400.52
87	-CH <sub>2</sub> -	H	4-(1-piperidinyl-ethoxy)-phenyl	2-(t-butyl-dimethyl-silyloxy)	8-fluoro	
89	-CH <sub>2</sub> -	H	S <sup>*</sup> -4-(piperidinyl-ethoxy)-phenyl	2-t-butyl carbonyl-oxy	8-hydroxy	555.68
90	-CH <sub>2</sub> -	H	S <sup>*</sup> -4-(piperidinyl-ethoxy)-phenyl	2-hydroxy	8-t-butyl carbonyl-oxy	555.68
91	-CH <sub>2</sub> -	H	R <sup>*</sup> -4-(piperidinyl-ethoxy)-phenyl	2-hydroxy	8-t-butylcarbonyloxy	555.68
92	-CH <sub>2</sub> -	H	R <sup>*</sup> -4-(piperidinyl-ethoxy)-phenyl	2-t-butyl carbonyl-oxy	8-hydroxy	557.67

93	-CH <sub>2</sub> -	H	S <sup>+</sup> -4-(piperidinyl-ethoxy)-phenyl	2-t-butyl carbonyl-oxy	8-fluoro	557.67
94	-CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>2</sub> -	H	hydroxy	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	540.85
95	-CH <sub>2</sub> -C(O)-CH <sub>2</sub> -	H	4-(piperidinyl-ethoxy)-phenyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	742.12
96	-CH <sub>2</sub> -C(O)-CH <sub>2</sub> -	H	4-(piperidinyl-ethoxy)-phenyl	2-hydroxy	8-hydroxy	513.6
97	-CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>2</sub> -	H	4-(piperidinyl-ethoxy)-phenyl	2-hydroxy	8-hydroxy	499.61
98	-CH <sub>2</sub> -	H	carboxymethyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	554.84
99	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>+</sup> -4-(piperidinyl-ethoxy)-phenyl	2-hydroxy	8-hydroxy	485.59
100	-CH <sub>2</sub> CH <sub>2</sub> -	H	S <sup>+</sup> -4-(piperidinyl-ethoxy)-phenyl	2-hydroxy	8-hydroxy	485.59
101	-CH <sub>2</sub> -	H	methoxy-carbonyl-methyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	568.86
102	-CH <sub>2</sub> -	H	methoxy-carbonyl-methyl	2-hydroxy	8-hydroxy	340.34
103	-CH <sub>2</sub> -	H	dimethylamino-n-propoxy-carbonyl-methyl	2-hydroxy	8-hydroxy	411.46
104	-CH <sub>2</sub> -	H	dimethylamino-ethoxy-carbonyl-methyl	2-hydroxy	8-hydroxy	397.43

105	-CH <sub>2</sub> -	H	pyrrolidinyl- ethoxy- carbonyl-methyl	2-hydroxy	8-hydroxy	423.47
106	-CH <sub>2</sub> -	H	piperidinyl- ethoxy- carbonyl-methyl	2-hydroxy	8-hydroxy	437.5
107	-CH <sub>2</sub> -	H	carboxy-methyl	2-hydroxy	8-hydroxy	326.31
108	-CH <sub>2</sub> -	H	morpholinyl- ethyl-amino- carbonyl-methyl	2-hydroxy	8-hydroxy	438.48
109	-CH <sub>2</sub> -	H	morpholinyl- ethoxy- carbonyl-methyl	2-hydroxy	8-hydroxy	439.47
110	-CH <sub>2</sub> -	H	morpholinyl-n- propyl-amino- carbonyl-methyl	2-hydroxy	8-hydroxy	452.51
111	-CH <sub>2</sub> -	H	pyrrolidinyl- ethyl-amino- carbonyl-methyl	2-hydroxy	8-hydroxy	422.49
112	-CH <sub>2</sub> -	H	allyl	2-hydroxy	8-hydroxy	308.34
113	-CH <sub>2</sub> -	H	3-hydroxy-n- propyl	2-hydroxy	8-hydroxy	326.35
114	-CH <sub>2</sub> -	H	allyl	2-(t-butyl- dimethyl- silyloxy)	8-(t-butyl- dimethyl- silyloxy)	536.87
115	-CH <sub>2</sub> -	H	(4-(4- fluorophenyl)- piperazinyl)- carbonyl-methyl	2-hydroxy	8-hydroxy	488.52
116	-CH <sub>2</sub> -	H	(4-(2-pyridyl)- piperazinyl)- carbonyl-methyl	2-hydroxy	8-hydroxy	471.52

117	-CH <sub>2</sub> -	H	4-(piperidinyl-ethoxy)-phenyl-carbonyl	2-hydroxy	8-hydroxy	499.57
119	-CH <sub>2</sub> -	H	3-hydroxy-n-propyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	554.88
120	-CH <sub>2</sub> -	H	carboxy-methyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	554.84
121	-CH <sub>2</sub> -	H	isopropoxy-carbonyl-methyl	2-hydroxy	8-hydroxy	368.39
122	-CH <sub>2</sub> -	H	2-hydroxy-ethyl	2-hydroxy	8-hydroxy	312.33
123	-CH <sub>2</sub> -	H	2-hydroxy-2-(4-piperidinyl-ethoxy-phenyl)-ethyl	2-hydroxy	8-hydroxy	515.61
124	-CH <sub>2</sub> -	H	4-(piperidinyl-ethoxy)-phenyl	-	8-hydroxy	455.56
125	-CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>2</sub> -	H	R <sup>*</sup> -4-(piperidinyl-ethoxy)-phenyl	2-hydroxy	8-hydroxy	499.61
126	-CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>2</sub> -	H	S <sup>*</sup> -4-(piperidinyl-ethoxy)-phenyl	2-hydroxy	8-hydroxy	499.61
127	-CH <sub>2</sub> -	H	R <sup>*</sup> -4-(piperidinyl-ethoxy)-phenyl	-	8-hydroxy	455.56
128	-CH <sub>2</sub> -	H	S <sup>*</sup> -4-(piperidinyl-ethoxy)-phenyl	-	8-hydroxy	455.56
129	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>*</sup> -4-(piperidinyl-ethoxy)-phenyl	2-hydroxy	8-fluoro	487.58

130	-CH <sub>2</sub> CH <sub>2</sub> -	H	S*-4-(piperidinyl-ethoxy)-phenyl	2-hydroxy	8-fluoro	487.58
131	-CH <sub>2</sub> CH <sub>2</sub> -	H	R*-4-(piperidinyl-ethoxy)-phenyl	-	8-hydroxy	469.59
132	-CH <sub>2</sub> CH <sub>2</sub> -	H	S*-4-(piperidinyl-ethoxy)-phenyl	-	8-hydroxy	469.59
133	-CH <sub>2</sub> -	H	4-(piperidinyl-ethoxy)-phenyl	2-hydroxy	-	455.56
134	-CH <sub>2</sub> -	H	4-(piperidinyl-ethoxy)-phenyl	2-t-butyl-carbonyl-oxy	-	539.68
135	-CH <sub>2</sub> -	H	hydroxy	2-(t-butyl-dimethyl-silyloxy)	-	382.54
136	-CH <sub>2</sub> -	H	hydroxy	-	-	252.27
137	-CH <sub>2</sub> -	H	4-(piperidinyl-ethoxy)-phenyl	-	-	439.56
138	-CH <sub>2</sub> CH <sub>2</sub> -	H	hydroxy	-	8-(t-butyl-dimethyl-silyloxy)	396.56
139	-CH <sub>2</sub> CH <sub>2</sub> -	H	hydroxy	2-(t-butyl-dimethyl-silyloxy)	-	396.56
140	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(piperidinyl-ethoxy)-phenyl	2-hydroxy	-	469.59
141	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(azepanyl-ethoxy)-phenyl	2-hydroxy	-	483.61

142	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(dimethyl-amino-ethoxy-phenyl)	2-hydroxy	-	429.52
143	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(azepanyl-ethoxy-phenyl)	-	8-hydroxy	483.61
144	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(dimethyl-amino-ethoxy-phenyl)	-	8-hydroxy	429.52
145	-CH <sub>2</sub> -	H	R <sup>+</sup> -4-(dimethyl-amino-ethoxy-phenyl)	-	8-hydroxy	415.49
146	-CH <sub>2</sub> CH <sub>2</sub> -	H	S <sup>+</sup> -4-(piperidiny-ethoxy)-phenyl	-	-	469.59
147	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>+</sup> -4-(dimethyl-amino-ethoxy-phenyl)	-	8-hydroxy	429.52
148	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>+</sup> -4-(piperidiny-ethoxy)-phenyl	-	-	469.59
149	-CH <sub>2</sub> CH <sub>2</sub> -	H	S <sup>+</sup> -4-(dimethyl-amino-ethoxy-phenyl)	-	8-hydroxy	429.52
150	-CH <sub>2</sub> CH <sub>2</sub> -	H	S <sup>+</sup> -4-(dimethyl-amino-ethoxy-phenyl)	2-hydroxy	-	429.52
151	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>+</sup> -4-(dimethyl-amino-ethoxy-phenyl)	2-hydroxy	-	429.52
152	-CH <sub>2</sub> CH <sub>2</sub> -	H	S <sup>+</sup> -4-(azepanyl-ethoxy-phenyl)	2-hydroxy	-	483.61
153	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>+</sup> -4-(azepanyl-ethoxy-phenyl)	2-hydroxy	-	483.61

154	-CH <sub>2</sub> CH <sub>2</sub> -	H	S <sup>*</sup> -4-(azepanyl-ethoxy-phenyl)	-	8-hydroxy	483.61
155	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>*</sup> -4-(azepanyl-ethoxy-phenyl)	-	8-hydroxy	483.61
156	-CH <sub>2</sub> CH <sub>2</sub> -	H	S <sup>*</sup> -4-(piperidinyl-ethoxy)-phenyl	2-methoxy	8-methoxy	513.64
157	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>*</sup> -4-(piperidinyl-ethoxy)-phenyl	2-methoxy	8-methoxy	513.64
158	-CH <sub>2</sub> -	H	4-(piperidinyl-ethoxy)-phenyl	2-(t-butyl-dimethyl-silyloxy)	-	569.82
159	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(azepanyl-ethoxy-phenyl)	2-hydroxy	8-hydroxy	499.61
160	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(diisopropyl-amino-ethoxy-phenyl)	2-hydroxy	8-hydroxy	501.63
161	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(dimethyl-amino-ethoxy-phenyl)	2-hydroxy	8-hydroxy	445.52
162	-CH(OCH <sub>3</sub> )-	H	4-(piperidinyl-ethoxy)-phenyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	730.11
163	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>*</sup> -4-(dimethyl-amino-ethoxy-phenyl)	2-hydroxy	8-hydroxy	445.52
164	-CH <sub>2</sub> CH <sub>2</sub> -	H	S <sup>*</sup> -4-(dimethyl-amino-ethoxy-phenyl)	2-hydroxy	8-hydroxy	445.52
165	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>*</sup> -4-(azepanyl-ethoxy-phenyl)	2-hydroxy	8-hydroxy	499.61

166	-CH <sub>2</sub> CH <sub>2</sub> -	H	S <sup>*</sup> -4-(azepanyl-ethoxy-phenyl)	2-hydroxy	8-hydroxy	499.61
167	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>*</sup> -4-(diisopropyl-amino-ethoxy-phenyl)	2-hydroxy	8-hydroxy	501.63
168	-CH <sub>2</sub> CH <sub>2</sub> -	H	S <sup>*</sup> -4-(diisopropyl-amino-ethoxy-phenyl)	2-hydroxy	8-hydroxy	501.63
169	-CH <sub>2</sub> -	H	S <sup>*</sup> -4-(piperidinyloxy)-phenyl	-	-	439.56
170	-CH <sub>2</sub> -	H	R <sup>*</sup> -4-(piperidinyloxy)-phenyl	-	-	439.56
171	-CH <sub>2</sub> -	H	S <sup>*</sup> -4-(piperidinyloxy)-phenyl	2-t-butyl carbonyloxy	-	539.68
172	-CH <sub>2</sub> -	H	R <sup>*</sup> -4-(piperidinyloxy)-phenyl	2-t-butyl carbonyloxy	-	539.68
173	-CH <sub>2</sub> -	H	R <sup>*</sup> -4-(piperidinyloxy)-phenyl	2-methoxy	8-methoxy	499.61
174	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(azepanyl-ethoxy-phenyl)	2-hydroxy	8-fluoro	501.6
175	-CH <sub>2</sub> -	H	S <sup>*</sup> -4-(piperidinyloxy)-phenyl	2-methoxy	8-t-butyl carbonyloxy	569.7
176	-CH <sub>2</sub> -	H	S <sup>*</sup> -4-(piperidinyloxy)-phenyl	2-methoxy	8-hydroxy	485.59
177	-CH <sub>2</sub> CH <sub>2</sub> -	H	S <sup>*</sup> -4-(azepanyl-ethoxy-phenyl)	2-hydroxy	8-fluoro	501.6



178	-CH <sub>2</sub> CH <sub>2</sub> -	H	R*-4-(azepanyl-ethoxy-phenyl)	2-hydroxy	8-fluoro	501.6
179	-CH <sub>2</sub> CH <sub>2</sub> -	H	R*-4-(piperidinyloxy)-phenyl	2-t-butyl carbonyloxy	8-t-butyl carbonyloxy	653.82
180	-CH <sub>2</sub> CH <sub>2</sub> -	H	S*-4-(piperidinyloxy)-phenyl	2-t-butyl carbonyloxy	8-t-butyl carbonyloxy	653.82
181	-CH <sub>2</sub> -	H	S*-4-(piperidinyloxy)-phenyl	2-hydroxy	8-methoxy	485.59
182	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(t-butyl-dimethylsilyloxy-ethoxy)-phenyl	2-t-butyl-dimethylsilyloxy	8-t-butyl-dimethylsilyloxy	775.27
183	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(3-hydroxy-n-propoxy)-phenyl	2-hydroxy	8-hydroxy	432.48
184	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(2-hydroxy-ethoxy)-phenyl	2-hydroxy	8-hydroxy	418.45
185	-CH <sub>2</sub> CH <sub>2</sub> -	H	hydroxy	2-t-butyl-dimethylsilyloxy	9-methyl	410.59
186	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(2-hydroxy-ethoxy)-phenyl	2-t-butyl-dimethylsilyloxy	8-t-butyl-dimethylsilyloxy	646.98
187	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(formyl-methoxy)-phenyl	2-t-butyl-dimethylsilyloxy	8-t-butyl-dimethylsilyloxy	644.96
188	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(carboxy-methoxy)-phenyl	2-t-butyl-dimethylsilyloxy	8-t-butyl-dimethylsilyloxy	660.96
189	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(methoxy-carbonyl-methoxy)-phenyl	2-t-butyl-dimethylsilyloxy	8-t-butyl-dimethylsilyloxy	674.99

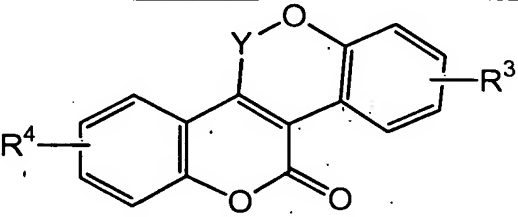
190	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(methoxy-carbonyl-methoxy)-phenyl	2-hydroxy	8-hydroxy	446.46
191	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(3-hydrox-n-propoxy)-phenyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	661.01
192	-CH <sub>2</sub> -	H	4-(piperidinyl-ethoxy)-phenyl	2-methoxy	8-methoxy	499.61
193	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(formyl-methoxy)-phenyl	2-t-butyl-dimethyl-silyloxy	8-t-butyl-dimethyl-silyloxy	658.99
194	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(2-carboxy-ethoxy)-phenyl	2-t-butyl-dimethyl-silyloxy	8-t-butyl-dimethyl-silyloxy	674.99
195	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>+</sup> -4-(piperidinyl-ethoxy)-phenyl	2-methoxy	8-hydroxy	499.61
196	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>+</sup> -4-(piperidinyl-ethoxy)-phenyl	2-hydroxy	8-methoxy	499.61
197	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(2-methoxy-carbonyl-ethoxy)-phenyl	2-t-butyl-dimethyl-silyloxy	8-t-butyl-dimethyl-silyloxy	689.02
198	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(2-carboxy-ethoxy)-phenyl	2-hydroxy	8-hydroxy	446.46
199	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(2-methoxy-carbonyl-ethoxy)-phenyl	2-hydroxy	8-hydroxy	460.49
200	-CH <sub>2</sub> CH <sub>2</sub> -	H	S <sup>+</sup> -4-(2-hydroxy-ethoxy)-phenyl	2-t-butyl-dimethyl-silyloxy	8-t-butyl-dimethyl-silyloxy	646.98
201	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>+</sup> -4-(2-hydroxy-ethoxy)-phenyl	2-t-butyl-dimethyl-silyloxy	8-t-butyl-dimethyl-silyloxy	646.98

202	-CH <sub>2</sub> CH <sub>2</sub> -	H	S <sup>*</sup> -4-(3-hydroxy-n-propoxy)-phenyl	2-t-butyl-dimethyl-silyloxy	8-t-butyl-dimethyl-silyloxy	661.01
203	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>*</sup> -4-(3-hydroxy-n-propoxy)-phenyl	2-t-butyl-dimethyl-silyloxy	8-t-butyl-dimethyl-silyloxy	661.01
204	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>*</sup> -4-(piperidinyl-2,6-dione-ethoxy)-phenyl	2-t-butyl-dimethyl-silyloxy	8-t-butyl-dimethyl-silyloxy	742.08
205	-CH <sub>2</sub> CH <sub>2</sub> -	H	Hydroxy	2-t-butyl-dimethyl-silyloxy	8-fluoro	414.55
206	-CH <sub>2</sub> CH <sub>2</sub> -	H	Hydroxy	2-t-butyl-dimethyl-silyloxy	-	396.56
207	-CH <sub>2</sub> CH <sub>2</sub> -	H	Hydroxy	2-t-butyl-dimethyl-silyloxy	9-methyl	410.59
208	-CH <sub>2</sub> CH <sub>2</sub> -	H	Hydroxy	-	8-t-butyl-dimethyl-silyloxy	396.56
209	-CH <sub>2</sub> -	H	Hydroxy	-	8-t-butyl-dimethyl-silyloxy	382.54
276	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(piperidinyl-ethoxy)-phenyl	2-hydroxy	8-hydroxy	483.61
277	-CH <sub>2</sub> CH <sub>2</sub> -	H	S <sup>*</sup> -4-(pyrrolidinyl-2,5-dione-ethoxy)-phenyl	2-hydroxy	8-hydroxy	499.53
278	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>*</sup> -4-(pyrrolidinyl-2,5-dione-ethoxy)-phenyl	2-hydroxy	8-hydroxy	499.53
279	-CH <sub>2</sub> CH <sub>2</sub> -	H	R <sup>*</sup> -4-(pyrrolidinyl-2,5-dione-n-propoxy)-phenyl	2-hydroxy	8-hydroxy	513.55

280	-CH <sub>2</sub> CH <sub>2</sub> -	H	S*-4-(pyrrolidinyl-2,5-dione-n-propoxy)-phenyl	2-hydroxy	8-hydroxy	513.55
281	-CH <sub>2</sub> CH <sub>2</sub> -	H	R*-4-(methoxyethoxy)-phenyl	2-hydroxy	8-hydroxy	432.48
282	-CH <sub>2</sub> CH <sub>2</sub> -CH <sub>2</sub> -	H	4-(piperidinyl-ethoxy)-phenyl	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	
283	-CH <sub>2</sub> CH <sub>2</sub> -	H	4-(piperidinyl-ethoxy)-phenyl	2-hydroxy	9-methyl	
286	-CH <sub>2</sub> CH <sub>2</sub> -	H	Hydroxy	2-(t-butyl-dimethyl-silyloxy)	8-fluoro	
300	-CH <sub>2</sub> CH <sub>2</sub> -	H	R*-4-(piperidinyl-ethoxy)-phenyl	2-methoxy	8-methoxy	513.64
301	-CH <sub>2</sub> CH <sub>2</sub> -	H	R*-4-(piperidinyl-ethoxy)-phenyl	2-methoxy	8-hydroxy	499.61
302	-CH <sub>2</sub> CH <sub>2</sub> -	H	R*-4-(piperidinyl-ethoxy)-phenyl	2-hydroxy	8-methoxy	499.61

The symbol "–" indicates that no R<sup>3</sup> or R<sup>4</sup> substituent was present.

**Table 3**

				
ID No	Y(*)	R <sup>3</sup>	R <sup>4</sup>	Calc MW
56	-CH <sub>2</sub> CH <sub>2</sub> -	2-hydroxy	8-hydroxy	296.27
57	-CH <sub>2</sub> CH <sub>2</sub> -	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	524.24
58	-CH <sub>2</sub> -C(O)-	2-hydroxy	8-hydroxy	310.26
59	-CH <sub>2</sub> -C(O)-	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	538.78
211	-CH <sub>2</sub> -C(O)-CH <sub>2</sub> -	2-hydroxy	8-hydroxy	324.29
212	-CH <sub>2</sub> -C(O)-CH <sub>2</sub> -	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	552.82
214	-CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> -	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	538.84
215	-CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> -	2-hydroxy	8-hydroxy	310.31
216	-CH <sub>2</sub> -CH(OH)-CH <sub>2</sub> -	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	554.84
218	-CH <sub>2</sub> -	2-hydroxy	-	266.26
219	-CH <sub>2</sub> -	2-(t-butyl-dimethyl-silyloxy)	-	380.52
220	-CH <sub>2</sub> CH <sub>2</sub> -	-	8-(t-butyl-dimethyl-silyloxy)	394.55
221	-CH <sub>2</sub> CH <sub>2</sub> -	2-(t-butyl-dimethyl-silyloxy)	-	394.55
222	-CH <sub>2</sub> -	2-methyl-carbonyl-oxy	8-methyl-carbonyl-oxy	366.33
223	-CH <sub>2</sub> CH <sub>2</sub> -	-	8-hydroxy	280.28

224	-CH <sub>2</sub> CH <sub>2</sub> -	2-hydroxy	9-methyl	294.31
225	-CH <sub>2</sub> CH <sub>2</sub> -	2-hydroxy	-	280.28
226	-CH <sub>2</sub> CH <sub>2</sub> -	2-hydroxy	8-fluoro	298.27
227	-CH <sub>2</sub> CH <sub>2</sub> -	2-t-butyl-dimethyl-silyloxy	8-fluoro	412.54
228	-CH <sub>2</sub> CH <sub>2</sub> -	2-t-butyl-dimethyl-silyloxy	9-methyl	408.57
287	-CH <sub>2</sub> CH <sub>2</sub> -	2-hydroxy	9-methyl	
288	-CH <sub>2</sub> CH <sub>2</sub> -	2-(t-butyl-dimethyl-silyloxy)	8-fluoro	

(\*) Within the table, the Y group is defined as it fits into the structure.

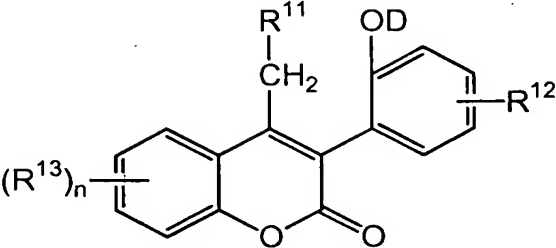
Thus when Y is -CH<sub>2</sub>C(O)- the -CH<sub>2</sub> is bound to the B ring and the C(O)- is bound to the O.

The symbol " - " indicates that no R<sup>3</sup> or R<sup>4</sup> substituent was present.

5

Representative examples of intermediates in the preparation of the compounds of formula (I) are as listed in Table 4 and 5, below.

**Table 4**

					
ID No	R <sup>12</sup>	(R <sup>13</sup> ) <sub>n</sub>	D	R <sup>11</sup>	Calc MW
60	8-Benzyloxy	2-Benzyloxy	Benzoyl	-CH(OH)-phenyl	702.71
61	8-hydroxy	2-hydroxy	H	-CH(OH)-phenyl	390.38
62	8-hydroxy	2-hydroxy	H	-CH <sub>2</sub> OH	314.29

63	8-(2-SEMoxy)	2-(2-SEMoxy)	SEM	-CH(OH)- phenyl	781.17
64	8-(2-SEMoxy)	2-(2-SEMoxy)	SEM	-CH(OH)- CH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>	747.16
65	8-Benzoyl-oxy	2-Benzyloxy	Benzoyl	-C(O)-phenyl	596.58
66	8-(2-SEMoxy)	2-(2-SEMoxy)	SEM	-CH <sub>2</sub> OH	705.07
67	8-MOMoxy	2-MOMoxy	MOM	-CHO	444.43
68	8-MOMoxy	2-MOMoxy	MOM	-CH <sub>2</sub> OH	446.44
69	8-(2-SEMoxy)	2-(2-SEMoxy)	SEM	-C(O)OCH <sub>3</sub>	733.08
70	8-(2-SEMoxy)	2-(2-SEMoxy)	SEM	-C(O)O- phenyl	796.15
71	8-hydroxy	2-hydroxy	H	-C(O)O- phenyl	404.37
72	8-(2-SEMoxy)	2-(2-SEMoxy)	SEM	-CHO	703.06
73	8-Methoxy	2-Methoxy	methyl	H	326.34
74	8-Methoxy	2-Methoxy	methyl	Br	405.24
75	8-(2-SEMoxy)	2-(2-SEMoxy)	SEM	H	675.05
76	8-(2-SEMoxy)	2-(2-SEMoxy)	SEM	Br	753.94
77	8-hydroxy	2-hydroxy	H	Br	363.16
78	8-MOMoxy	2-MOMoxy	MOM	H	416.42
79	8-MOMoxy	2-MOMoxy	MOM	Br	495.32
80	8-Benzyloxy	2-Benzyloxy	Benzoyl	H	596.58
81	8-Pivaloyloxy	2-Pivaloyloxy	Pivaloyl	H	536.61
82	8-hydroxy	2-hydroxy	H	H	284.07
83	8-Benzyloxy	2-Benzyloxy	Benzyl	Br	674.06
229	2-trimethylsilyl- ethoxy-methoxy	8-trimethylsilyl- ethoxy- methoxy	trimethylsilyl- ethoxy- methyl	iodomethyl	814.99
230	2-trimethylsilyl- ethoxy-methoxy	8-trimethylsilyl- ethoxy- methoxy	trimethylsilyl- ethoxy- methyl	chloromethyl	723.53

231	2-hydroxy	8-hydroxy	H	chloromethyl	332.74
232	2-hydroxy	8-hydroxy	H	iodomethyl	424.19
233	2-trimethylsilyl-ethoxy-methoxy	8-trimethylsilyl-ethoxy-methoxy	trimethylsilyl-ethoxy-methyl	phenoxy-carbonyl	797.19
234	2-hydroxy	8-hydroxy	H	chloromethyl-carbonyl	360.75
236	2-hydroxy	8-hydroxy	H	1-phenyl-1-hydroxy-methyl	392.41
237	2-methoxy-methoxy	8-methoxy-methoxy	methoxy-methyl	chloromethyl-carbonyl	492.91
238	2-trimethylsilyl-ethoxy-methoxy	8-trimethylsilyl-ethoxy-methoxy	trimethylsilyl-ethoxy-methyl	chloromethyl-carbonyl	751.55
239	2-methoxy	-	methyl	H	296.33
240	2-methoxy	-	methyl	bromo	375.22
241	-	-	methyl	H	266.3
242	2-methoxy	8,10-dimethoxy	methyl	bromo	435.27
243	-	-	methyl	bromo	345.2
244	-	-	H	bromo	331.17
247	2-methoxy	7-methoxy	methyl	H	326.35
248	2-methoxy	8-methoxy	methyl	chloromethyl-carbonyl	402.83
251	-	-	methyl	4-methoxy-phenyl	372.42
252	-	-	H	4-hydroxy-phenyl	344.37

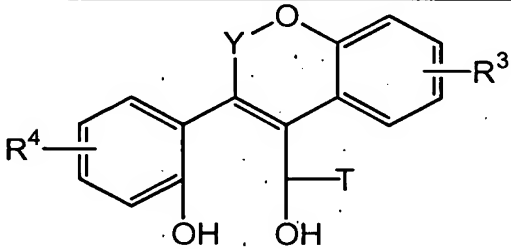


254	-	-	methyl-carbonyl	bromo and 4-methoxy-carbonyl-phenyl	507.34
255	2-methoxy	8-methoxy	methyl	methoxy-methyl-carbonyl	398.42
256	2-trimethylsilyl-ethoxy-methoxy	8-trimethylsilyl-ethoxy-methoxy	trimethylsilyl-ethoxy-methyl	trimethylsilyl-ethoxy-methyl	805.33
257	2-methoxy-methoxy	8-methoxy-methoxy	methoxy-methyl	trimethylsilyl-ethoxy-methyl	546.7
258	2-methoxy	8-methoxy	methyl	trimethylsilyl-ethoxy-methyl	456.62
259	2-methoxy	-	methyl	trimethylsilyl-ethoxy-methyl	426.59
260	2-methoxy	-	methyl	methoxy-methyl	340.38
261	-	8-methoxy	methyl	methoxy-methyl	340.38
262	-	8-methoxy	methyl	trimethylsilyl-ethoxy-methyl	426.59
263	-	8-fluoro	methyl	trimethylsilyl-ethoxy-methyl	414.55

264	2-methoxy	8-fluoro	methyl	trimethylsilyl- ethoxy- methyl	444.58
265	2-methoxy	8-fluoro	methyl	methoxy- methyl	358.37
266	2-methoxy	9-methyl	methyl	methoxy- methyl	354.41
267	2-methoxy	9-methyl	methyl	trimethylsilyl- ethoxy- methyl	440.62
268	2-hydroxy	9-methyl	H	hydroxy- methyl	312.33
269	2-hydroxy	-	H	hydroxy- methyl	298.3
270	2-hydroxy	8-fluoro	H	hydroxy- methyl	316.29
271	-	8-hydroxy	H	hydroxy- methyl	298.3
284	-	8-fluoro	methyl	H	
285	2-methoxy	8,10-dimethoxy	H	H	
289	-	8-methoxy	methyl	H	
290	-	9-methyl	methyl	H	

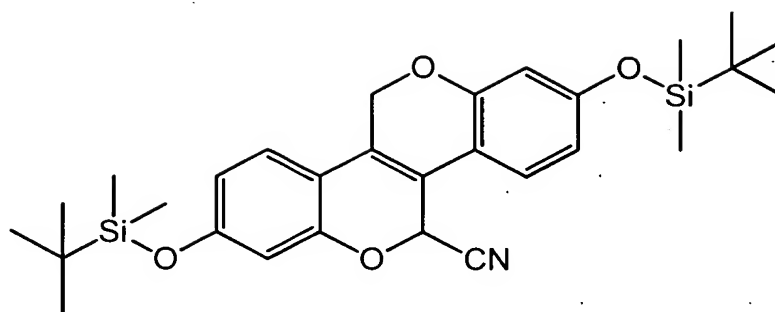
The symbol " - " indicates that no R<sup>12</sup> or R<sup>13</sup> substituent was present.

**Table 5**

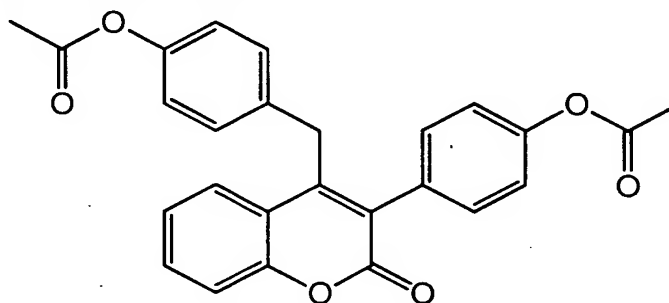
					
ID No	R <sup>3</sup>	R <sup>4</sup>	Y	T	Calc MW
249	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	-CH <sub>2</sub> CH <sub>2</sub> -	4-(hydroxy-n-propoxy)-phenyl	679.02
245	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	-CH <sub>2</sub> CH <sub>2</sub> -	4-(piperidinyl-ethoxy)-phenyl	587.84
246	-	-	-CH <sub>2</sub> -	4-(piperidinyl-ethoxy)-phenyl	457.57
235	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	-CH <sub>2</sub> CH <sub>2</sub> -	4-(piperidinyl-ethoxy)-phenyl	732.13
291	2-(t-butyl-dimethyl-silyloxy)	8-(t-butyl-dimethyl-silyloxy)	-CH <sub>2</sub> CH <sub>2</sub> - CH <sub>2</sub> -	4-(piperidinyl-ethoxy)-phenyl	

The symbol “-” indicates that no R<sup>3</sup> or R<sup>4</sup> substituent was present.

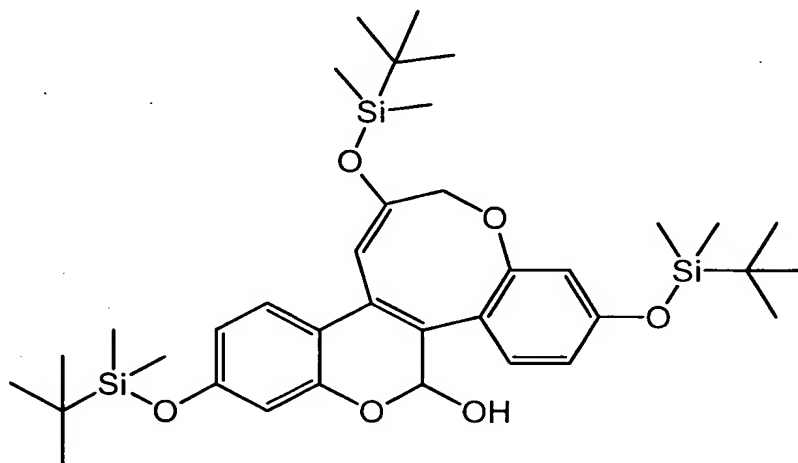
- 5 Additional compounds prepared as intermediates in the synthesis of the compounds of the present invention, include the following:



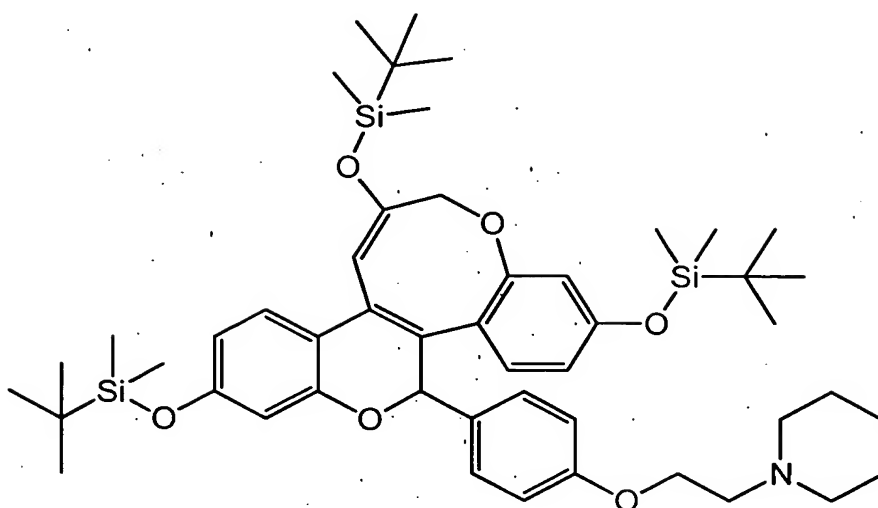
also known as 2,8-bis-(tert-butyl-dimethyl-silyloxy)-5,11-dihydro-chromeno[4,3-c]chromene-5-carbonitrile;



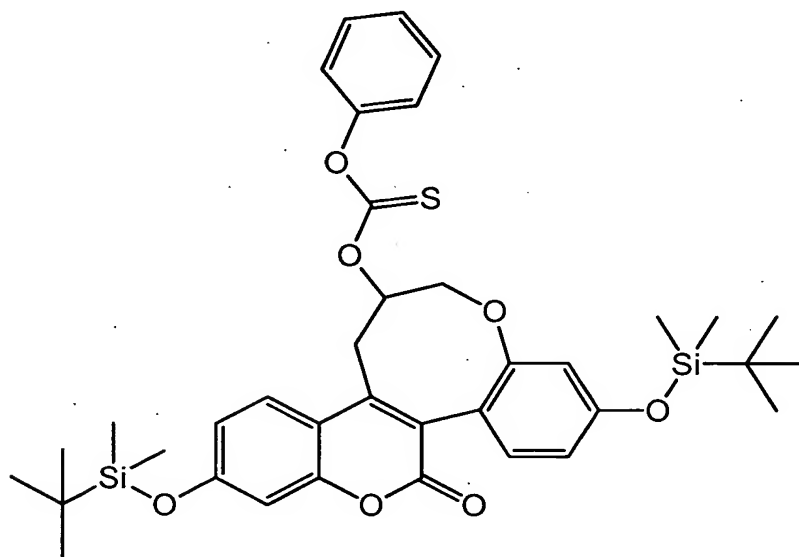
5 also known as acetic acid 4-[4-(4-acetoxy-benzyl)-2-oxo-2H-chromen-3-yl]-phenyl ester;



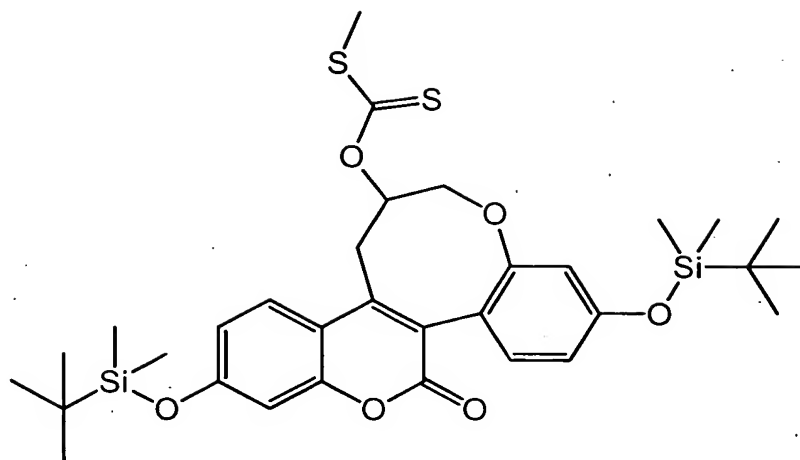
also known as 2,6,12-tris[[(1,1-dimethylethyl)dimethylsilyl]oxy]-3,9-dihydro-[1]benzopyrano[4,3-e][1]benzoxocin-9-ol;



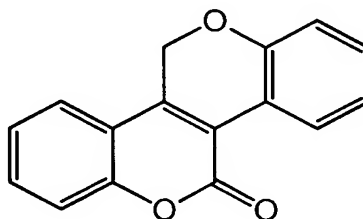
also known as 1-[2-[4-[2,6,12-tris[[(1,1-dimethylethyl)dimethylsilyl]oxy]-3,9-dihydro[1]benzopyrano[4,3-e][1]benzoxocin-9-yl]phenoxy]ethyl]-piperidine;



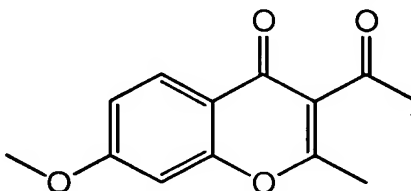
5 also known as O-[6,12-bis[[(1,1-dimethylethyl)dimethylsilyl]oxy]-1,2,3,9-tetrahydro-9-oxo[1]benzopyrano[4,3-e][1]benzoxocin-2-yl] O-phenyl ester carbonothioic acid;



also known as O-[6,12-bis[[[1,1-dimethylethyl]dimethylsilyl]oxy]-1,2,3,9-tetrahydro-9-oxo[1]benzopyrano[4,3-e][1]benzoxocin-2-yl] S-methyl ester carbonodithioic acid;



also known as 11H-chromeno[4,3-c]chromen-5-one; and



also known as 3-acetyl-7-methoxy-2-methyl-chromen-4-one.

### Example 172

#### Estrogen Receptor $\alpha$ Flash Plate Assay

This assay monitors binding of radiolabeled estrogen to the estrogen receptor. It is performed on a BioMek 2000 (Beckman). Plates are read in a scintillation counter (Packard TopCount), with decreased counts an indication of binding of a compound to the receptor. The assay was run according to the procedure described by Allan, et al., *Anal. Biochem.* (1999), 275(2), 243-247.

On day one, 100  $\mu$ L of Estrogen Screening Buffer (ESB, Panvera) containing 5mM dithiothreitol (DTT, Panvera), 0.5  $\mu$ g mouse anti-estrogen receptor monoclonal antibody (SRA-1010, Stressgen) and 50 ng purified human estrogen receptor  $\alpha$  (Panvera) were added to each well of a 96 well FlashPlate Plus plate crosslinked with goat anti-mouse antibodies (NEN Life Sciences). The plate was sealed and incubated at 4°C overnight.

On day two, each well was washed three times with 200  $\mu$ L PBS, pH 7.2, at room temperature. To each well was then added 98  $\mu$ L radiolabeled estrogen (0.5 nM, which equals 6 nCi for a 120 Ci/mmol batch, Amersham), diluted in ESB and 5mM dithiothreitol (DTT). To individual wells were then added 2.5  $\mu$ L test compound diluted in 30% (v/v) dimethyl sulfoxide/50 mM HEPES, pH 7.5. The wells were mixed three times by aspiration, the plate sealed and incubated at room temperature for one hour. The wells were then counted for 1 min in a TopCount scintillation counter (Packard).

### **Example 173**

#### **Estrogen Receptor $\beta$ Fluorescence Polarization Assay**

This assay monitors binding of a fluorescent analog of estrogen (Fluormone ES2, Panvera) to the estrogen receptor. Plates are read in a fluorometer that can be set to polarization mode. A decrease in fluorescence relative to vehicle control is an indication of binding of a compound to the receptor.

It is crucial to avoid introduction of air bubbles into the reaction in each well of the 96 well plate throughout this procedure. (Bubbles on the surface of the reaction disrupt light flow, affecting the polarization reading.) However, it is also crucial to effectively mix the reaction components upon addition to the well.

On ice, a 2X standard mixture of Assay Buffer (Panvera), 10 nM DTT and 40 nM ES2 was prepared. On ice, a 2X reaction mixture of Assay Buffer (Panvera), and 20 nM hER- $\beta$  (Panvera) and 40 nM ES2 was also prepared.

Dilutions of test compound were prepared in 30% (v/v) dimethyl sulfoxide/50 mM HEPES, pH 7.5. At this point, the dilutions were 40X the final required concentration.

5 The standard mixture at 50  $\mu$ L was then added to each well. The reaction mixture at 48  $\mu$ L was added to all wells. The compound dilution at 2.5  $\mu$ L was added to the appropriate wells. The reaction mixtures were mixed using a manual pipette, a roll of aluminum foil adhesive cover was placed on the plate and the plate incubated at room temperature for 1 hour.

10 Each well on the plate was then read in an LjL Analyst with an excitation wavelength of 265 nm and an emission wavelength of 538.

Representative compound of the present invention were tested according to the procedure described above for binding to the Estrogen Receptor  $\alpha$  and Estrogen Receptor  $\beta$ , with results as listed in Table 6.

15

**TABLE 6**

ID No	Estrogen Receptor $\alpha$ in $\mu$ M (No.)	Estrogen Receptor $\beta$ in $\mu$ M (No.)
1	0.505 (4)	0.061
2	>10K (4)	>10K (4)
6	0.013 (2)	0.016 (4)
9	.0023 (2)	0.084 (2)
11	0.009 (2)	0.7 (6)
13	0.006 (2)	0.026 (2)
14	0.0074 (4)	0.15 (4)
15	0.017 (4), 0.0064	0.017 (4), 0.028
17	0.0014 (2)	0.031 (2)
19	0.0019 (2)	0.099 (2)
21	0.015 (2)	0.011 (2)
22	3.45 (2)	>10K (2)
24	5.95 (4)	>10K (2)



25	1.2 (2)	>10K (2)
26	0.014 (5)	0.02 (4)
27	0.69 (2)	>10K (2)
28	0.14 (2)	6.25 (2)
29	0.004 (4)	0.017 (4)
30	>10K (4)	>10K (4)
33	NA	NA
41	1.9 (2)	>10K (2)
43	0.62 (2)	0.165 (2)
89	>1.00	>1000
90	0.0066	90
99	0.0039	10
100	0.0026	20
125	0.079	28
126	0.0042	30
131	0.061	220
132	0.0048	66
146	0.0062	99
147	0.180	190
148	0.0036	26
149	0.015	34
150	0.019	110
151	0.014	25
152	0.0086	110
153	0.0066	23
154	0.0042	35
155	0.088	140
163	0.013	12
164	0.0028	24
165	0.0016	11
166	0.0018	20

167	0.0070	13
168	0.0042	28
169	0.072	1000
170	0.160	460
171	0.140	1000
172	0.260	1000
173	0.170	1000
174	0.0015, 0.0013	29,18
175	0.660	1000
176	0.024	1000
177	0.040	330
178	0.0064, 0.0076	181.5, 360
179	1.00	1000
180	1.00	1000
181	0.0011	10
183	0.014	9.1
190	0.0089	16
195	0.125	200
196	0.055	595
276	0.024	260
300	0.060	>10
301	0.0041	0.189
302	0.0116	0.355

NA indicates no detected activity at test concentration;

#### **Example 174**

##### **MCF-7 Cell Proliferation Assay**

- 5 This assay was run according to the procedure described by Welshons, et al., (*Breast Cancer Res. Treat.*, **1987**, 10(2), 169-75), with minor modification.

Briefly, MCF-7 cells (from Dr. C. Jordan, Northwestern University) were maintained in RPMI 1640 phenol red free medium (Gibco) in 10% FBS

(Hyclone), supplemented with bovine insulin and non-essential amino acid (Sigma). The cells were initially treated with 4-hydroxytamoxifen ( $10^{-8}$  M) and let stand at 37°C for 24 hours. Following this incubation with tamoxifen, the cells were treated with compounds at various concentrations.

5

Compounds to be tested in the agonist mode were added to the culture media at varying concentrations. Compounds to be treated in the antagonist mode were prepared similarly, and 10 nM 17 $\beta$ -estradiol was also added to the culture media. The cells were incubated for 24 hours at 37°C. Following this incubation, 0.1  $\mu$ Ci of  $^{14}$ C-thymidine (56mCi/mmol, Amersham) was added to the culture media and the cells were incubated for an additional 24 hours at 37°C. The cells were then washed twice with Hank's buffered salt solution (HBSS) (Gibco) and counted with a scintillation counter. The increase in the  $^{14}$ C-thymidine in the compound treated cells relative to the vehicle control cells were reported as percent increase in cell proliferation.

15

Representative compound of the present invention were tested according to the procedure described above, with results as listed in Table. 7.

20

**TABLE 7**

ID No	Agonist (No.) (nM)	Antagonist (No.) (nM)
1	1200 (1)	>10K (1)
2	>10K (1)	>10K (1)
6	97 (1)	>10K (1)
9	>10K (12)	777 (6)
11	>10K (1)	246 (3)
13	>10K (1)	1400 (1)
14	>10K (7)	5600 (2)
15	>10K (7)	6.25 (2)
17	>10K (1)	3580 (1)
19	>10K (6)	713 (4)

21	>10K (4)	970 (4)
22	>10K (8)	662 (7)
24	>10K (6)	672 (6)
25	>10K (10)	1393 (6)
26	64.3 (3)	>10K (3)
27	NA	NA
28	NA	NA
29	NA	NA
30	>10K (1)	2200 (1)
33	>10K (1)	4800 (1)
41	>10K (1)	>10K (1)
43	>10K (1)	>1K (1)
89		845
90		1670
99		182
100		75
125		4700
126		245
131		>10000
132		1280
146		1123
147		>10000
148		997
149		1360
150		2940
151		2760
152		2612
153		1274
154		1437
155		>10000
163		687

164		293
165		401
166		217
167		424
168		220
169		10000
170		10000
171		5100
172		2280
173		>10000
174		1744
175		5000
176		>10000, 4000
177		3000
178		1476
179		1866
180		655
181		1335
183		10000
190		>10000
195		>1000
196		>1000
276		4680
300		17.36
301		0.340
302		0.928

NA indicates no detected activity at test concentration;

### **Example 175**

**Alkaline Phosphatase Assay in Human Endometrial Ishikawa Cells**

This assay was run according to the procedure described by Albert et al., *Cancer Res*, (9910), 50(11), 330-6-10, with minor modification.

5 Ishikawa cells (from ATCC) were maintained in DMEM/F12 (1:1) phenol red free medium (Gibco) supplemented with 10% calf serum (Hyclone). 24 hours prior to testing, the medium was changed to DMEM/F12 (1:1) phenol red free containing 2% calf serum.

10 Compounds to be tested in the agonist mode were added to the culture media at varying concentrations. Compounds to be treated in the antagonist mode were prepared similarly, and 10 nM 17 $\beta$ -estradiol was also added to the culture media. The cells were then incubated at 37°C for 3 days. On the fourth day, the media was removed, 1 volume of 1X Dilution Buffer (Clontech) was added to the well followed by addition of 1 volume of Assay Buffer (Clontech).  
 15 The cells were then incubated at room temperature for 5 minutes. 1 volume of freshly prepared Chemiluminescence Buffer (1 volume of chemiluminescent substrate (CSPD) in 19 volume Chemiluminescent Enhancer with final concentration of CSPD at 1.25 mM; Sigma Chemical Co.) was added. The cells were incubated at room temperature for 10 minutes and then quantified on a  
 20 luminometer. The increase of chemiluminescence over vehicle control was used to calculate the increase in alkaline phosphatase activity.

Representative compound of the present invention were tested according to the procedure described above, with results as listed in Table 8.

25

**Table 8**

ID No	Agonist (No.) (nM)	Antagonist (No.) (nM)
1	130 (1)	>10K (1)
2	>10K (1)	>10K (1)
6	33 (2)	>10K (1)
9	>10K (12)	110 (7)
11		80 (1)

13	>10K (2)	228 (2)
14	>10K (11)	149 (6)
15	>10K (11)	112 (7)
17	>10K (6)	513 (5)
19	>10K (1)	250 (1)
21	>10K (9)	830 (8)
22	>10K (11)	53.5 (11)
24	>10K (9)	66 (10)
25	>10K (11)	235 (10)
26	>10K (5)	180 (1)
27	NA	NA
28	NA	NA
29	NA	NA
30	>10K (1)	630 (1)
33	>10K (1)	1000 (1)
41	>10K (1)	550 (1)
43	>10K (1)	1600 (1)
89		10
90		57
99		130
100		19
125		1620
126		78
131		4940
132		548
146		154
147		>10000
148		138
149		1020
150		850
151		605

152		324
153		509
154		167
155		3770
163		405
164		61
165		128
166		41
167		35
168		287
169		830
170		2664
171		56.7
172		68.4
173		>10000
174		135
175		300
176		>10000, 793
177		259
178		125
179		9
180		0.9
181		34
183		3000
190		>10000
195		739
196		229
276		481
300		>100
301		0.329
302		0.571



NA indicates no detected activity at test concentration;

**Example 176**

5 As a specific embodiment of an oral composition, 100 mg of the compound #22, prepared as in Example 54 is formulated with sufficient finely divided lactose to provide a total amount of 580 to 590 mg to fill a size O hard gel capsule.

10

While the foregoing specification teaches the principles of the present invention, with examples provided for the purpose of illustration, it will be understood that the practice of the invention encompasses all of the usual variations, adaptations and/or modifications as come within the scope of the  
5 following claims and their equivalents.